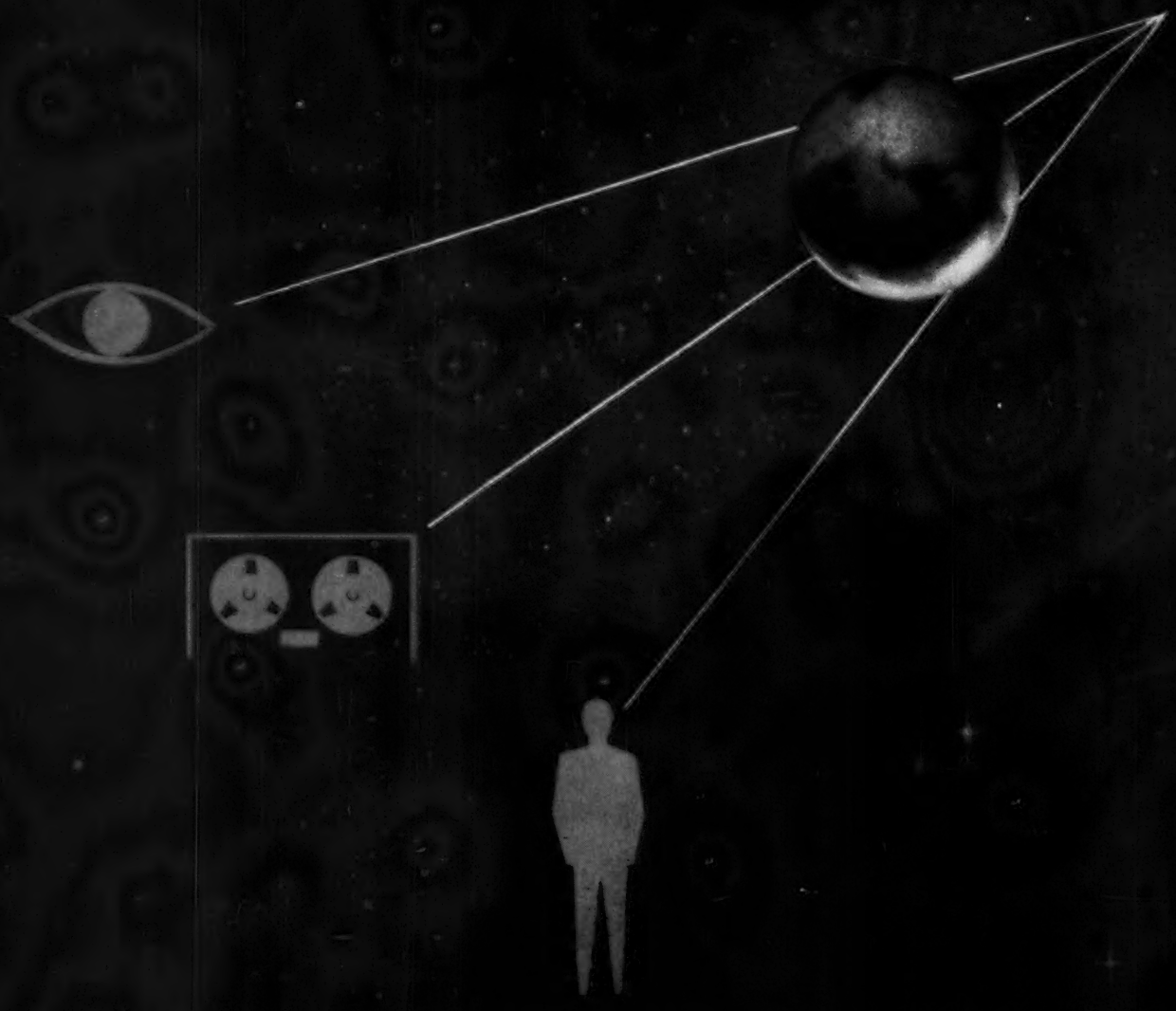
AEROSPACE MANAGEMENT

FOR TECHNICAL DECISION-MAKING AND LONG-RANGE PLANNING

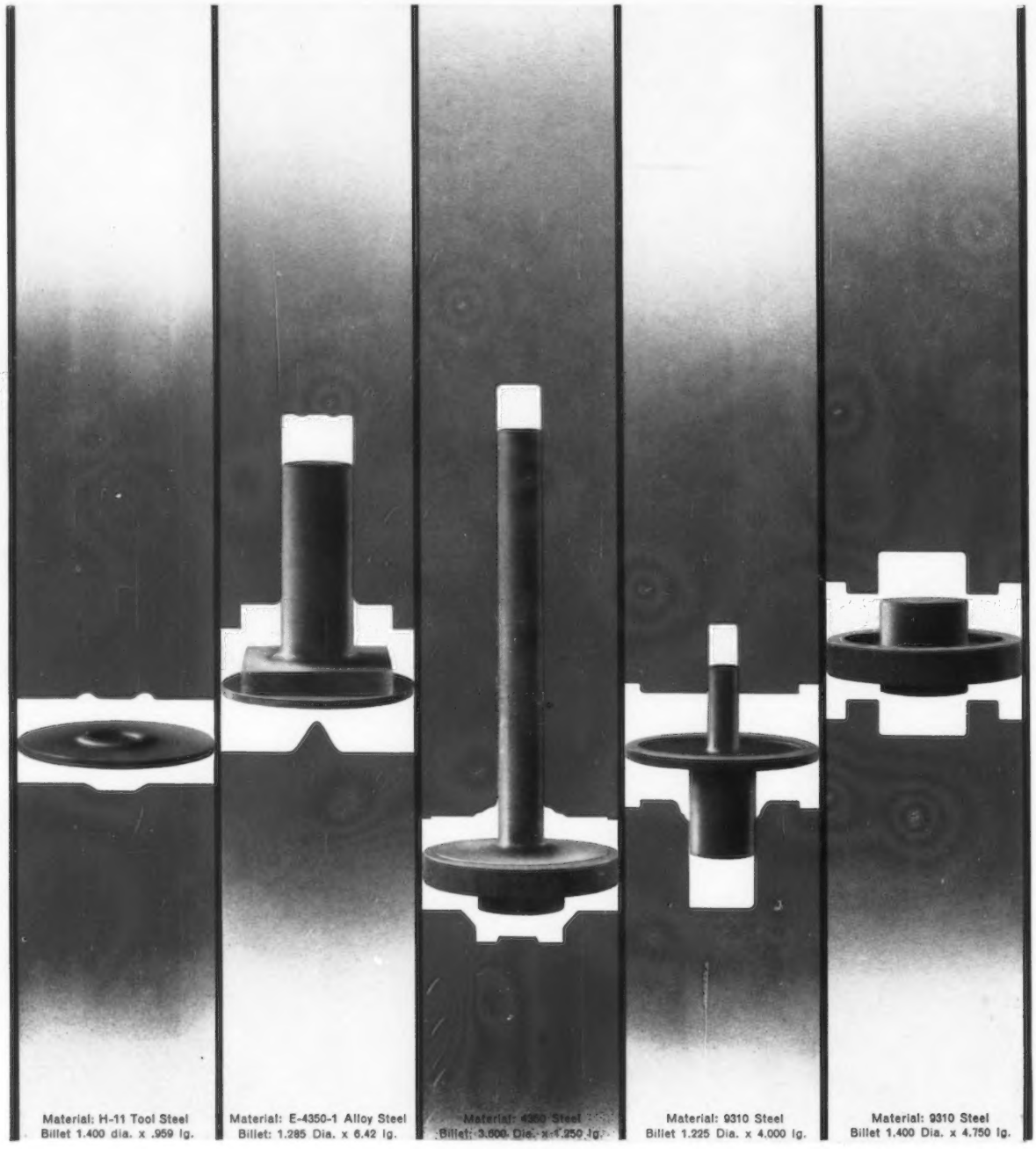
A Chilton Publication

October 1961



ANNUAL FORECAST ISSUE

Defense Budgeting...Avionics...Solid Boosters...Computers in Management...Communications Satellites...Man-in-Space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Billet 1.400 dia. x .959 lg.
Material: E-4350-1 Alloy Steel
Billet: 1.285 Dia. x 6.42 lg.
Material: 4350 Steel
Billet: 3.600 Dia. x 4.250 lg.
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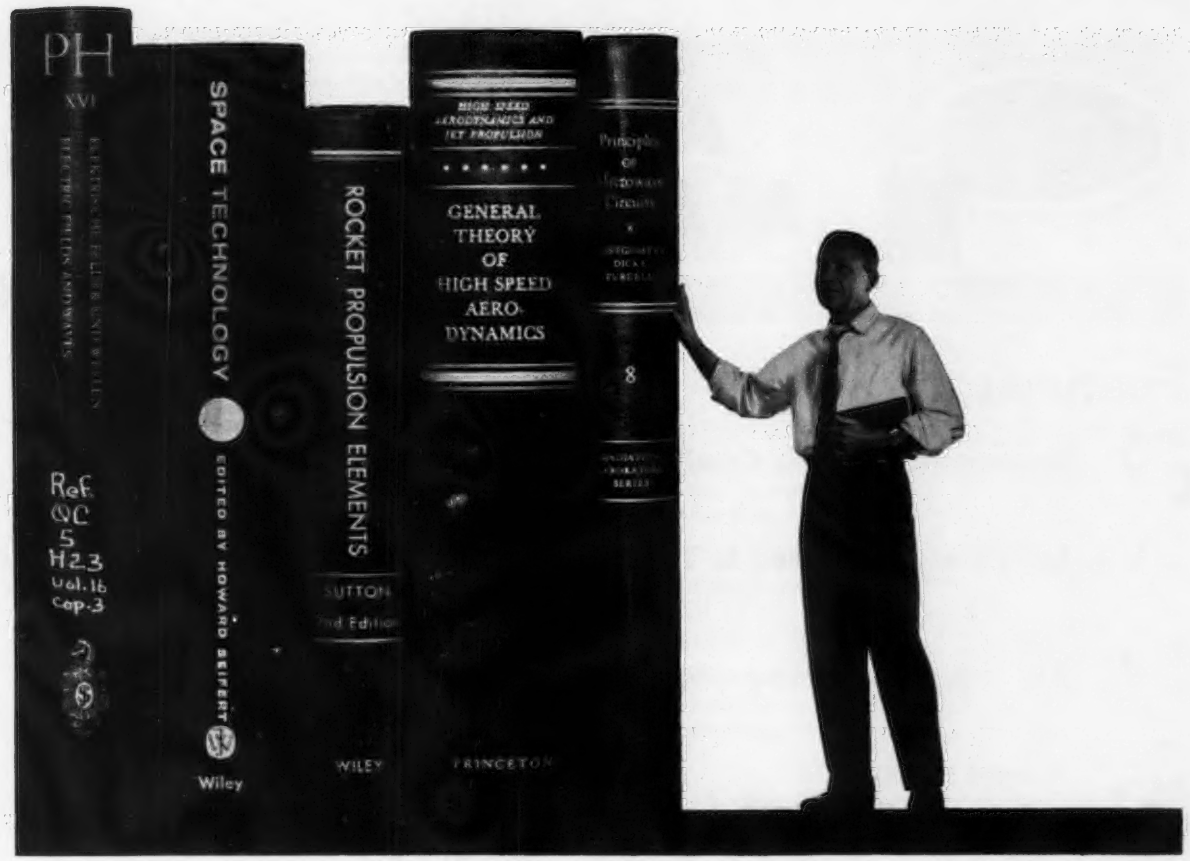

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AEROSPACE MANAGEMENT

FOR TECHNICAL DECISION-MAKING AND LONG-RANGE PLANNING

October, 1961 Volume 4, Number 10

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THE COVER STORY—The attribute of "vision" is as difficult to depict as it is to find. This rare ingredient is what makes planning for the future meaningful. Man has always been ready to pay a high price for this prophetic quality. Now, with the aid of computers, planning for the future is shifting from an intuitive process to a scientific one. Beginning on page 66 is a feature describing the role of the computer in decision making.

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COMING NEXT MONTH

THE SEARCH FOR NEW MATERIALS—From electronics, to structures, to propellants, the massive research program in materials is beginning to pay off. But the big rush is still to come.

IN THE NOVEMBER ISSUE: Managing A Materials Research Program; The Battle For Markets, Metals vs. Plastics vs. Glass; Are Transistors Already Obsolete?

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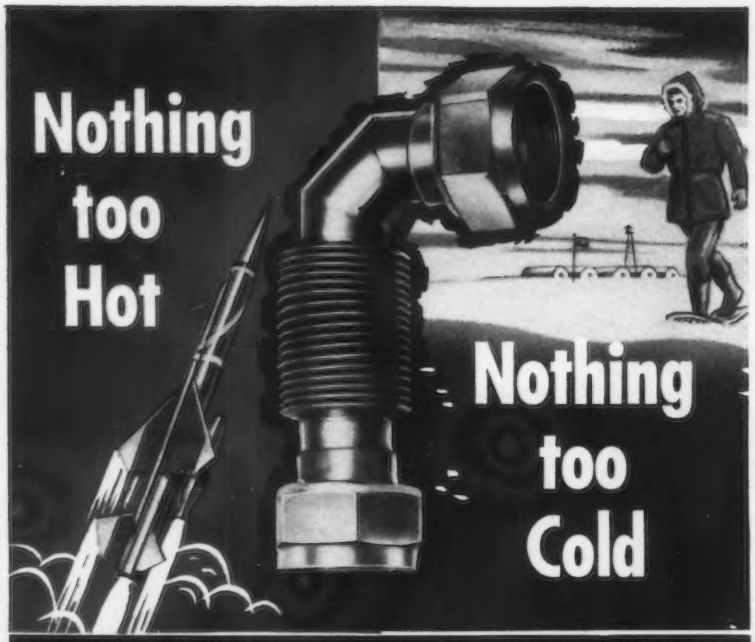

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Air Force Systems Command
Air Force Science and Engineering Symposium
Sheraton-Palace Hotel
San Francisco, Calif.

Oct. 9-11
National Electronics Conference
International Amphitheatre
Chicago, Ill.

Oct. 9-15
American Rocket Society
Space Flight Report to the Nation
New York Coliseum
New York, N. Y.

Oct. 16-18
The Magnesium Association
17th Annual Convention
Belmont Plaza Hotel
New York, N. Y.

Oct. 23-24
Aerospace Industries Association
Manufacturing Committee Conference
Summit Hotel
New York, N. Y.

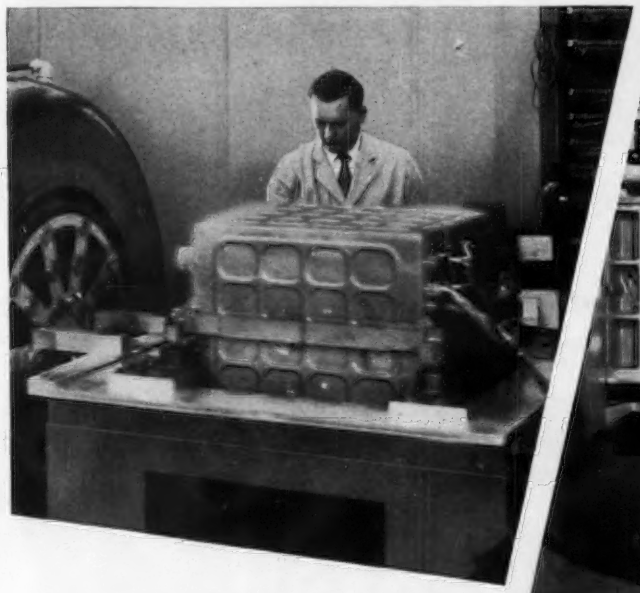
Oct. 23-27
American Society for Metals
1961 National Metal Show
Cobo Hall
Detroit, Mich.

Oct. 24-26
International Symposium on
Aero-Space Nuclear Propulsion
Riviera Hotel, Las Vegas, Nev.

Oct. 25-26
Armour Research Foundation
1961 Computer Applications Symposium
Morrison Hotel
Chicago, Ill.

Oct. 30-Nov. 1
Air Traffic Control Association
Sixth Annual Meeting and
Air Traffic Control Exposition.
Deauville Hotel
Miami Beach, Fla.

ARMA SYSTEMS



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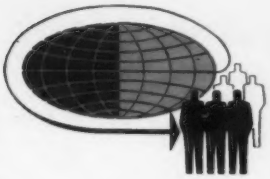


EDITORIAL

Don't Acquiesce—Speak Up

How often in the Aerospace industry do we hear this statement? "The government is our main source of income, so don't quote us." There seems to be a constant feeling of "let's not offend anyone" as a bargain between income and self-respect.

Government seems to have the idea that any shortcomings on its part can be blamed on that overgrown snivelling kid—American industry—which must be **controlled** at all costs. And, it does cost! Take an example. From January to June, 66,844 civilian employees were added just to the Executive Branch of the government. One congressman points out that this is seven new employees every five minutes of a working day.

Sure, as each day sheds its light, industry gets more controls heaped upon its already weighted financial back. What do you do about it? Well, you complain among yourselves at industry meetings. You tell your stockholders when the dividends drop off. But, do you band together and present a logical, well-documented case to the government? Seldom.

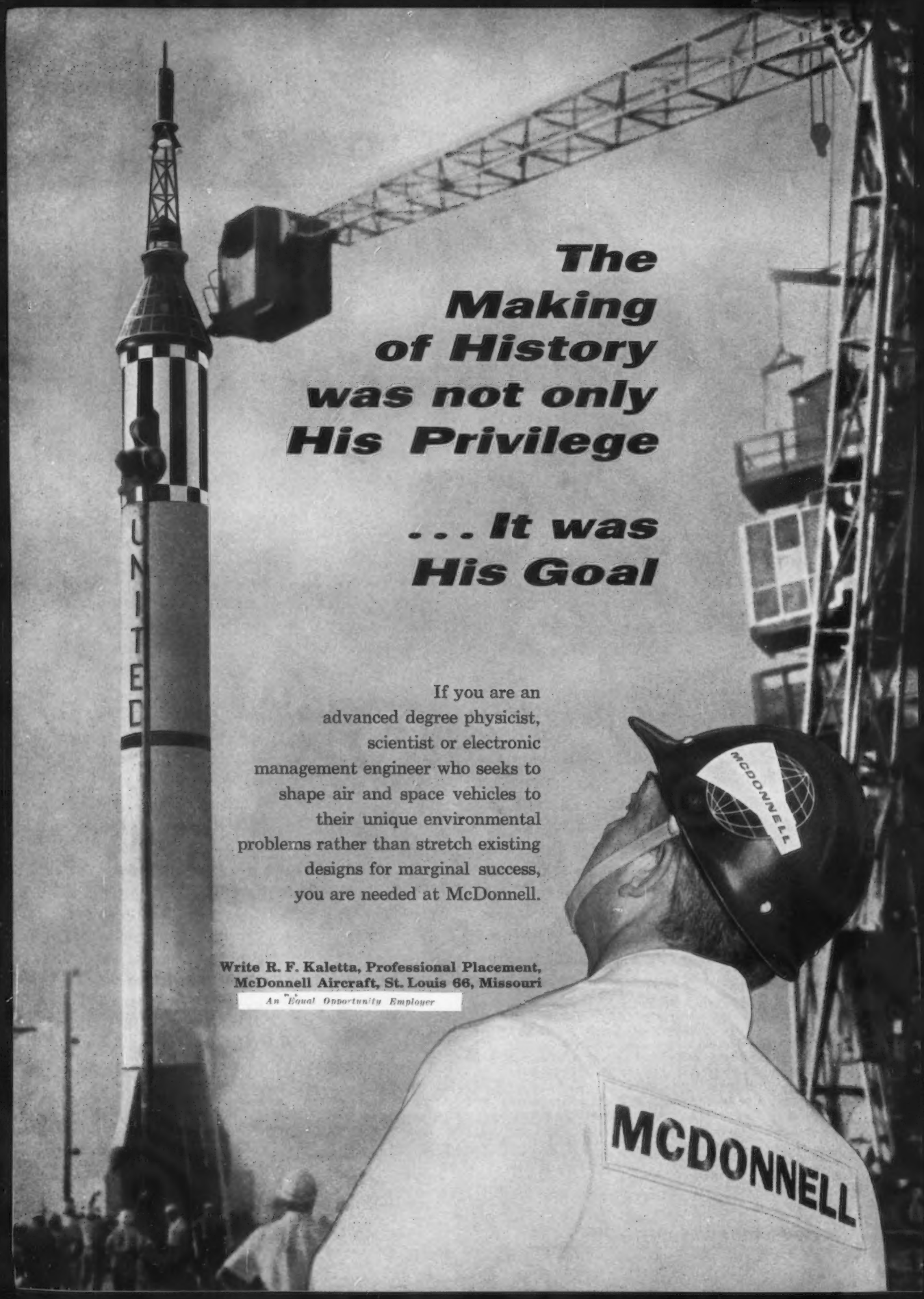
Too many times inconclusive evidence is presented before Congressional committees and government officials in order to support the industry position on bureaucratic legislation that should be "killed in committee." When industry does band together in a trade association to state its collective case, the harmony is often off-key and there are too many who just mouth-the-words.

Why shouldn't industry speak up for the free enterprise system? Is it so-un-American to do so? We think its just plain, old, ordinary common sense. If your product is good, your price is fair, and you have the capability, you have every right to fight socialistic business tendencies on the part of government.

What has industry done about renegotiation, the ASPR's, minimum wage, and a host of other things on the docket? Are we going to go along with new controls without raising our voices in protest? Take the time to read some of the regulations forced on you instead of letting the government interpret them in glib press releases.

Tom MacNew

Editor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Letters to the Editor

Timely—Easily Read

. . . I have reviewed the August 1961 edition and find the content of timely attention and easily read. It is obviously a very good publication for the technical managerial reader.

E. W. Grenfell, VADM
U. S. Navy

AM Underscored

. . . At your suggestion I have just leafed through the August issue of AEROSPACE MANAGEMENT and have been surprised at the amount of underscoring and marginal notation that my first reading occasioned.

A. H. Drain
Magnolia, Ohio

Immediate Application

. . . I am glad to be able to tell you that I have found AEROSPACE MANAGEMENT to be an extremely interesting magazine. My Colleagues and I have found that several of the articles had applicability to our immediate problems.

C. W. Clark, Brig. Gen.
Chief, R & D Division
Ordnance HQ
Dept. of the Army

The Broader Perspective

. . . While at it, perhaps, a bit premature to base one's comments on only one issue, I will say that I believe a magazine having a primary focus of attention on problems of managing military systems will be of considerable value to myself and probably to others as well . . . feature articles were interesting and readable.

Most of the problems I have encountered in the management field have been produced or aggravated by the fact that technically trained specialists have difficulty in viewing a situation in a broader perspective than that furnished by their own discipline. There is a great need for general information on overall government defense (and arms control) goals, policies and programs, and the techniques which all of us, in one way or another, develop to try to align our activities, effectively and profitably, at whatever level, with the greater military/industrial structure of which we are a part. If your magazine can contribute to the developing art of management in this complex area, it will be welcome indeed.

Robert L. Hamilton
Economic Factors Dept.
The MITRE Corp.

. . . *continued on next page*

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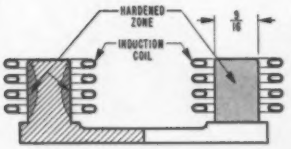

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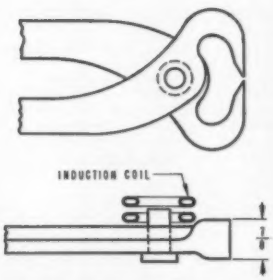

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Letters

continued

Fills the Need

. . . I have long felt that there was a real need for a publication that concentrated on the management aspects of the Aerospace field rather than simply attempting to duplicate the more technical articles of several other magazines.

Harold J. Black
Director of Engineering
Avco Corp

. . . I should like to congratulate you, and your organization, for having the foresight to present such a valuable magazine to the aerospace industry.

Theodore Ulmer, Pres.
Astro Reliability Corp.

Away from the Technical

. . . I am frankly happy to see a magazine devoted to management as many of we engineers have long since parted with the technical details of the business. We all need an insight to better ways to organize, plan and supervise if we are to prosper and expand in the industry.

D. W. Michler
Administrator, Value Engineering
Military Electronics Div.
Motorola, Inc.

Concurs on Reliability

. . . I have read the excellent article, Cutting the Cost of Reliability (Sept. 1961) . . . article pointed out many views which are held by myself.

Peter E. Young
Senior Reliability Engineer
Lockheed Aircraft Corp.

Appreciates Accuracy

. . . We thought that AEROSPACE MANAGEMENT did an excellent job on the article about UTC (How UTC Invaded A Major Market, Aug. 1961) and are most appreciative of its tone and accuracy. The rest of the articles were well done and interesting, too, and the indications are that the new magazine will fill a need very capably.

Gen. D. L. Putt, USAF (Ret.)
President, United Technology Corp.

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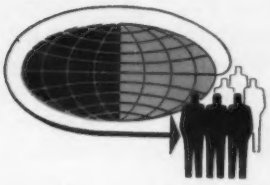


Projects

Missiles and Space Vehicles

AEROBEE — An Aerobee Junior rocket was successfully fired from a flooded test basin recently. The rocket floated upright in 25 ft of water before firing with only the top 10 in. above the surface. Success of first water-launch of liquid-fueled rocket clears the way for actual launchings at sea.

BIG BOOSTERS—Boeing conducting research on the problems anticipated in development on one million to nine million pound boosters. AF contract calls for work in propellant feed systems, propellant rankage, tank pressurization and interaction of these systems with the missile auxiliary power systems.

BIRDIE — New system, Battery Integration Radar Display Equipment, is a transistorized version of the Missile Master, the giant nation-wide coordinating communications system. Birdie will be used to process and distribute information about aircraft to guided missile batteries and coordinate Nike Ajax and Nike Hercules missile fire. It can operate independently in its own area or as part of an over-all system. System, built by Martin, occupies 97 per cent less space than Missile Master; uses 95 per cent less power; and 80 per cent fewer personnel. Average unit costs about half a million dollars.

BLOODHOUND 2—Mark 2 anti-aircraft model recently intercepted and destroyed a fast jet target aircraft at well under 1000 ft. Introduction of continuous wave radar guidance and other improvements increased low level capability of Bristol/Ferranti missile.

BOMARC B—Flight test series for advanced B model interceptor missile completed. Highlight of program was a maximum range test in which one of the missiles performed an intercept 400 miles from the launch site at an altitude above 60,000 ft. Boeing has delivered tactical versions to Eglin AFB for crew training and missile service test program.

DYNA-SOAR—McDonnell Aircraft has proposed a Dyna-Soar type system to Navy as part of its fleet air defense. Carrier-launched boost-glide system would be used against ICBMs. Concept is considered feasible and power plant could be developed from present technology.

MHD ENGINE — Convair exploring use of magnetohydrodynamic engine for deep space propulsion. One pound thrust plasma engine may come out of research conducted since July 1960.

NIKE ZEUS—Army successfully fired a Nike Zeus recently in a test to evaluate a new solid propellant rocket motor in the second stage. Thiokol made the new second stage motor, also produces the 450,000 lb thrust first stage motor.

RANGER—Four additional Ranger spacecraft have been added to the existing NASA Ranger Lunar Exploration Program bringing the total to be launched in the early phase of the program to nine. The four new Rangers will be used to transmit TV pictures of the moon surface up to the moment of impact. JPL will construct the vehicles and RCA the TV systems.

SATURN — Ryan Electronics has received a half million dollar contract to develop high-altitude altimeters for Saturn. First Saturn launch later this year will not need radar altimeter because relatively low altitudes of about 100 miles will permit land-based and shipboard tracking.

SD-5—Combat surveillance drone, equipped for the first time with its inertial guidance system, had a successful flight tenth flight recently. Fairchild-Stratos has received an additional $2.9-million for continuing development of the SD-5 jet drone surveillance system.

SOVIET ROCKETS—Preceding recent testing of rockets into central Pacific, Marshall Kiril S. Moskalenko, commander of Soviet rocket forces, declared that 95 per cent of all Soviet rockets fired reach their targets. The marshall claimed that the Soviet Union could wipe out NATO defense bases with short range tactical nuclear rockets alone.

Project Progress

continued

SPADATS—New space detection and tracking system may be working within four years. System's improvement will enable it to provide space traffic control; identify purpose and capability of enemy space vehicles; support anti-satellite weapons; and provide support to U. S. space activities. Ling-Temco-Vought is studying a ship-based anti-satellite system. Land-based system, such as Spadat, would be used at first.

SPAROAIR—Two Sparrow rocket motors were used to build a two-stage unguided missile. Launched by a Navy F4D, the probe reached an altitude of more than 64 miles. Nine more launches will be made. Sparoair give Navy an economical research rocket using a standard weapons system booster.

TGAM-83—Martin-Baltimore will build 424 trainer missiles under a $1.5-million contract from AF. Missiles will be used in training F-100 jet pilots in use of GAM-83, AF version of Bullpup.

TRAILBLAZER II — Fourth stage payload vehicle will power-dive from 190-mile altitude as part of re-entry physics studies. General Electric MSVD is building six vehicles. Launchings will begin this year from Wallops Island.

X-15—Joe Walker piloted X-15 to 3,645 mph record despite trouble. Flight plan called for a climb to 120,000 ft, but he went only to 112,000 because of fuel pressure failure. After cutting flight time from 12 to nine minutes, Walker explained: "I was getting hungry, so I came back in a hurry."

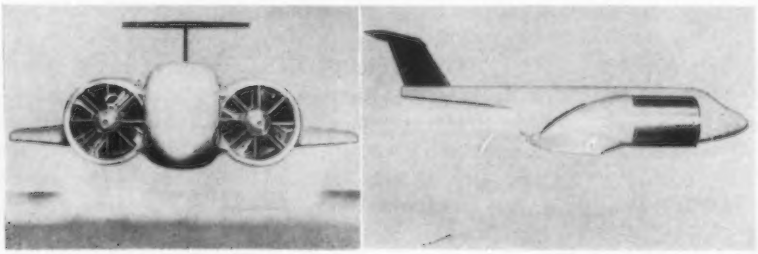
Aircraft and ASW

A4D-5 — Navy's newest modification of the A4D Douglas Skyhawk attack bomber is undergoing flight test at Edwards AFB. Additional weapon stations and the lighter, more powerful Pratt and Whitney J-52-P6 engines give it added performance and attack flexibility. Structural changes permit an increase in payload. Take-off distances for deck launchings are reduced.

B-52 — Role of the B-52 as a recoverable booster may be extended beyond X-15 and Dyna-Soar

DYNA-SOAR—Landing system for returning vehicles under development at GE's Defense Systems Dept. uses radar, a computer and radio to guide vehicles.

FLEX WING—Ryan, under Army contract, is doing prototype engineering on several configurations. Wing has been tested at speeds up to Mach 4.9.



◀ **GETOL** model being wind tunnel tested by Boeing Vertol. In ground effect take-off and landing, air is compressed by shrouded props and discharged through wing-slots to create air cushion. In flight, large airgates open to permit backward air discharge, creating forward thrust.

applications for launching combined booster-payload weights of more than 200,000 lb. Boeing studies show that the B-52 is "nearly optimum" to assist in the launching of satellites or other space vehicles. Substantial booster cost savings are possible over ground-launch-techniques, particularly for relatively small vehicles. A B-52 is being modified for launching the Dyna-Soar.

CANADAIR 44—Range and payload figures of swing-tail cargo transport have been increased as a result of structural modifications. An increase of 5000 lb in maximum take-off weight (to 210,000 lb) has extended range with full payload by 11 per cent. Payload with full fuel is raised by more than 15 per cent.

DC-8—During tests on new four per cent leading edge extension, a DC-8 went supersonic. Aircraft altitude recorded as 40,350 ft, speed more than 660 mph.

F-27F—Fairchild's improved transcontinental range version of its F-27 has received FAA certification. F version has increased maximum take-off gross weight of 39,400 lb. G model, with 42,000 lb take-off weight has been flight tested. Certification is expected in early 1962 on G model.

HUGHES LOH—Model 396 helicopter entered in Army light observation helicopter program. Five machines to be delivered to Army Aviation Board, Fort Rucker for evaluation and testing about 24 months after contract work begins. Army expects to eventually procure 4000 helicopters from across industry.

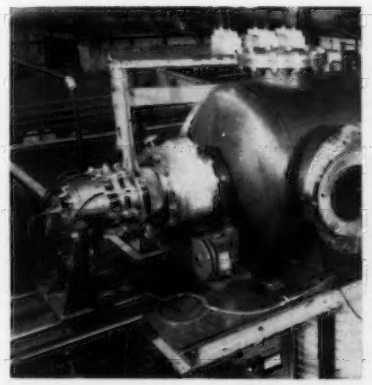
JETSTAR — FAA has granted its first type transport certificate to a compact jet, the four-engine Lockheed JetStar. JetStar will be entering AF service as a jet utility aircraft; 26 planes are expected to be in service by the end of this year.

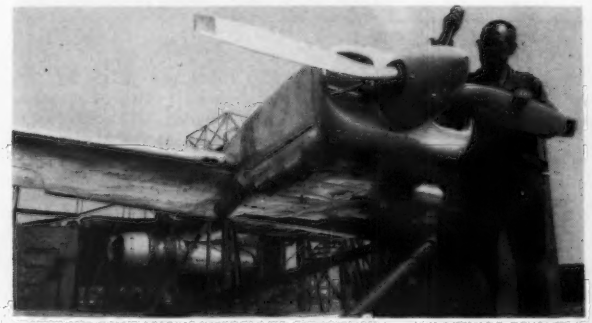
NIHON YS-11—Twin-engine turboprop transport will be the first designed and built in post-war Japan. This 60-passenger transport will have a 300 to 600 mi range. Sierracin Corp. has received a contract from Nihon Aeroplane Mfg. to produce the windshields and cockpit side panels. Nihon was formed in 1959 as a joint venture of the Japanese government and six major aircraft manufacturing companies.

880-M—A Swissair 880-M recently completed the longest non-stop flight ever made by a Convair jet transport. The 880-M flew 3,855 miles, from New York to Zurich. Its takeoff weight in New York was 183,000 lb. Its fuel load on arrival was 13,000 lb.

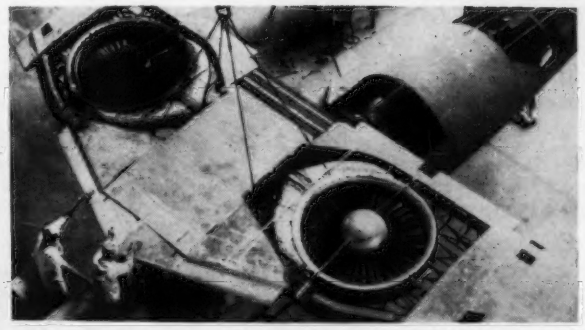
◀ **ASROC ASW ROCKET** trainer, built by Minneapolis-Honeywell for Naval Training Device Center. Engineer, Richard Vasak is shown with his right hand on the launch switch.

REPPAC III—Repetitively Pulsed ▶ Plasma Propulsion Engine (left foreground) attached to vacuum chamber. Engine produced 20 millipounds of thrust with a specific impulse of 5000 sec. GE said it operated at 32 per cent efficiency.



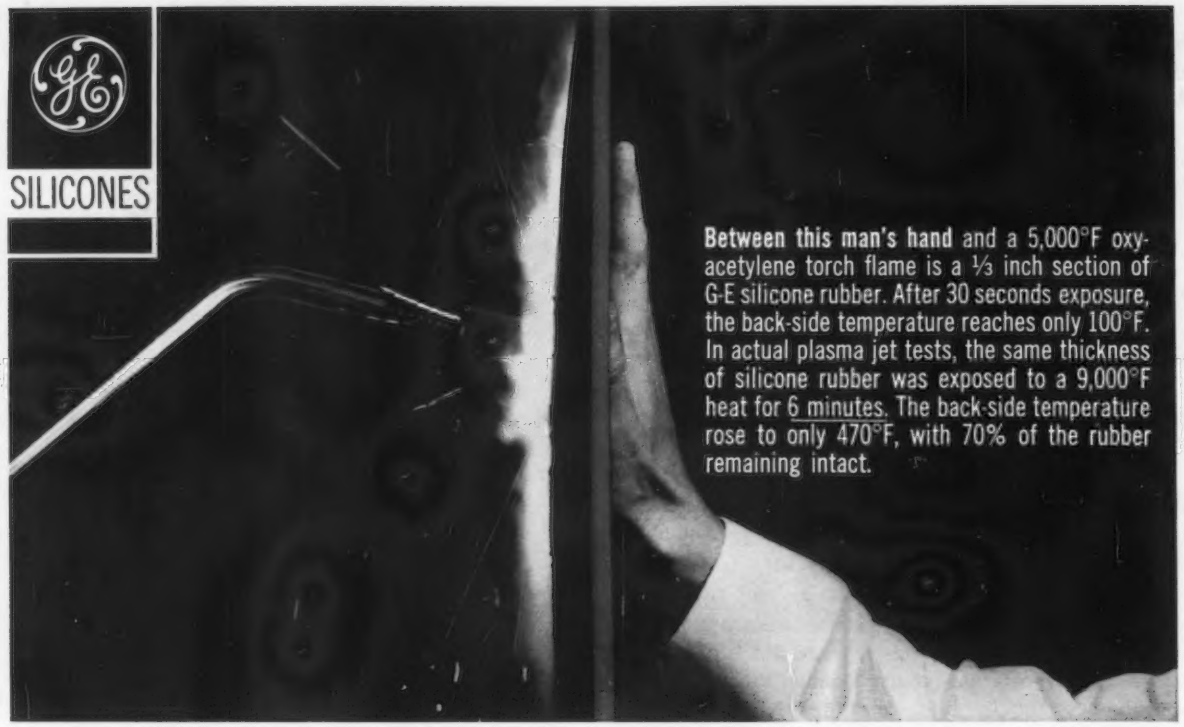


B-52's 17,000 lb thrust Pratt & Whitney turbofan engine teamed with engine from Cessna 310, for Boeing's tests of turbofan's stall and crosswind performance.



V/STOL—Full-scale model being prepared for wind tunnel testing of GE X-353 lift fan. Range is 500 mi with a cruising speed better than Mach .8.

SILICONES



Between this man's hand and a 5,000°F oxy-acetylene torch flame is a ⅓ inch section of G-E silicone rubber. After 30 seconds exposure, the back-side temperature reaches only 100°F. In actual plasma jet tests, the same thickness of silicone rubber was exposed to a 9,000°F heat for 6 minutes. The back-side temperature rose to only 470°F, with 70% of the rubber remaining intact.

Thermal barrier against 5000°F flame

GENERAL ELECTRIC SILICONE RUBBER

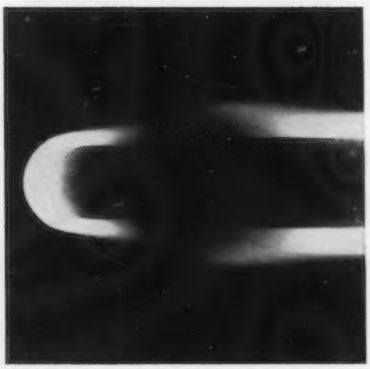
The surface of the tested rubber section forms a hard, carbonaceous crust, while the underside remains flexible and undamaged. Preliminary tests showed the effective heat of ablation to be eight times better than presently used plastics, with one-seventh the rate of ablation and one-fourth the weight loss. Here is an excellent ablative covering with low thermal conductivity.

RESULTS OF PLASMA JET TESTS AT 9,000°F

Flight Simulation
Vel. = 17,000 ft./sec.
Alt. = 250,000 ft.

Exposure time at 9,000°F	Back-side temperature of ⅓ inch section of G-E silicone rubber
30 seconds	100°F
2 minutes	210°F
3 minutes	300°F
4 minutes	375°F
5 minutes	430°F
6 minutes	470°F

The above chart shows how the high thermal insulation of G-E silicone rubber is maintained during exposure to 9,000°F heat. It is also useful in mechanical and electrical applications at temperatures from —150°F to 600°F, where it remains resilient and flexible. It also maintains its excellent physical and electrical properties over this wide temperature range for extended periods.



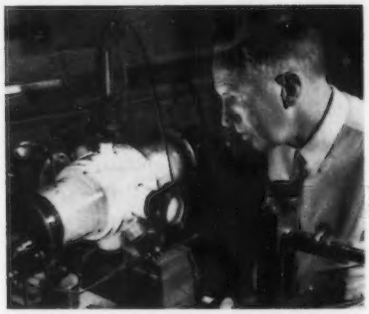
Continued high temperature testing goes on at General Electric's Missile and Space Vehicle Department in Philadelphia. Shown above is a typical specimen undergoing plasma jet testing in an electric arc heated supersonic wind tunnel. Continuous testing like this will develop new data on the thermal and ablative uses of G-E silicone rubber.

To learn more about G-E silicone rubber, and its uses as a thermal and ablative material, write: General Electric Company, Silicone Products Dept., Section BB1061, Waterford, New York.

GENERAL ELECTRIC

Technical Advances

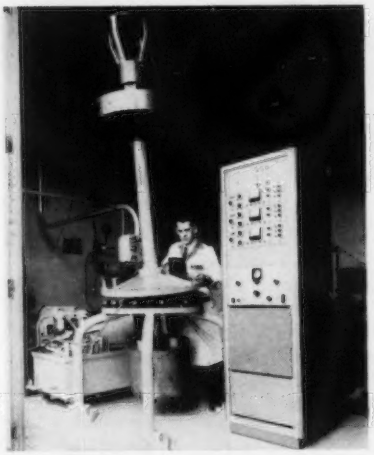
R & D BRIEFS



Landau damping theory has been successfully tested. Dr. Melvin J. Kofoid is shown with plasma-filled chamber with which he tested the 16-year-old Russian theory. The theory has been a cornerstone of research efforts in the field of plasma physics. It was advanced in 1945 but never substantiated until recent Boeing Scientific Research Lab. effort.

All-ceramic thermoelectric generator opens the way to obtaining electricity from waste heat, such as a rocket's exhaust. Minneapolis-Honeywell developed what it believes to be the first heat-resistant ceramic generator. Here, as shown on voltmeter, the device converts 2400° F heat of an electric furnace into 100 volts of electricity.

Space power generation system will weigh eight pounds for every 1000 watts produced in design proposed to AF by the Garrett Corp. Compact atomic reactor will heat and expand liquid metal through a turbine to produce electrical power for ion/cesium motors. While problems of extremely high loop temp in unit are said to have been solved, ground prototype tests are not expected before early 1966.



Space vehicle simulator, with the exact mass and moment distribution of a simulated space vehicle, is supported on a steel ball. The ball floats on oil, in a hydrostatic bearing. Vickers, Inc., built the simulator for use in the development of a new attitude control system. Simulator is free to move in three planes: pitch, yaw, and roll.

Sapphire whiskers have increased the strength of pure silver five times. GE research indicates that by similar blending of sapphire whiskers into ultra-strength metals, materials several times stronger at white heat than any high-strength alloy can be produced.

Miniature search coil pinpoints physical defects and property variations in small and inaccessible parts. Loop of induction coil at end of probe consists of 200 turns of insulated wire with .00065 in. diam. Iron core has .008 in. diam. Battelle Memorial Institute developed the coil.

Fuel cell can directly convert heat to electricity at efficiencies exceeding 50 per cent. Cell developed by Armour Research Foundation, can operate on solar heat, or from nuclear or waste heat sources.

EQUIPMENT

Television comparator permits examination and precise measurement of miniature solid objects, with magnification up to 300 times. Inventor, Warren Novak of General Precision, controls monitor with single aircraft-type control stick. Operator can position the image on the screen, and change its magnification through entire range without loss of focus.

. . . continued on next page

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VINCO GUARANTEES the Optical Master Inspection Dividing Head to be accurate within ± 1 second of arc; the ball bearing spindle runout to be 25 MILLIONTHS of an inch, total indicator reading; the master disc graduations to be spaced to an accuracy within ± ½ second of arc.

Shown above is a heavy duty dividing head and a dual recorder console with a ball slide electronic indicator stand. This ultra precision equipment will check and record tooth to tooth errors and accumulated errors to within 50 millionths of an inch on a 15" D.P. gear. Single recorder consoles are available.

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- Calibration of index plates, involute and master involute profiles.
- Calibration of lead bars or helical precision components.
- Inspection of two and three dimensional cams as well as ellipses, cycloids, etc.
- Measurement of angular transmission of motion by gears and gear trains.
- Measurement of angular displacement of turntables.

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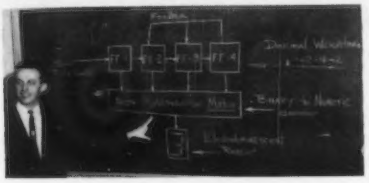
Technical Advances continued

Jammer transmitter, with reduced weight, complexity and cost, is said to be compatible with other countermeasures systems equipment now programmed for B-52 and other U. S. bombers. Most details are secret, but Sperry has substituted special high level noise sources for the conventional series of amplification stages now employed in radar jamming systems.



Electroluminescence creates light through the excitation of phosphors placed in an electrical field, eliminates the need for bulbs, vacuum and filaments. Sylvania development of compact, low power Panelescent display devices makes possible substantial progress in the design of electronic equipment used in data processing, radar countermeasures, air and sea traffic control. Elmer O. Stone, manager of electroluminescent applications, points out functions of a decimal coded binary switching matrix which uses photoconductors driven by neon lamps.

Test tanks and equipment that will permit an inner tank temp of —423° and an outer temp of 700° have been completed at Lockheed-Georgia. Equipment will be used in continued research on the problem of maintaining constant pressurization of liquid rocket fuel.

Image intensifier orthicon amplifies 100,000 times natural light otherwise too dim to see. RCA developed the device for the Army. It will enable field commanders to

observe and direct battlefront operations with TV without exposing troops to lights. It will operate on starlight, moonlight or natural skyglow. It has produced clear images on a picture screen on a dark and cloudy night.

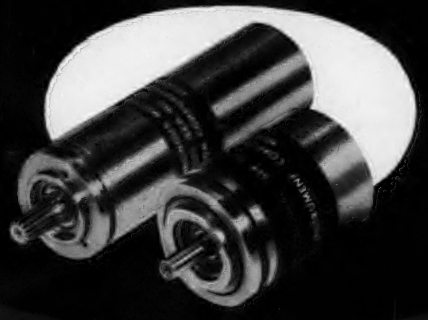
Electrical power generator enables radar to pinpoint targets more precisely. Electrical voltage variations which often show up as false readings on radar screens are eliminated. Alco Products Co., and Westinghouse developed unit for Army with their own funds. Subsequently, a $1.5-million contract was awarded to produce seven units.

PRODUCTION

Production-run flash welding of aluminum, magnesium and magnesium-thorium alloys is possible with process developed by Lockheed's California Div. Technique results in 40 per cent stronger welds for as much as 75 per cent lower processing costs. A modified 400 KVA flashwelder performs the work. Joints are said to be as strong as the parent metal. Welds are made automatically after the machine is pre-set by an operator.

Cryogenic forming process produces cases and pressure vessels with strengths of 260,000 psi. This strength is achieved by straining the vessel; stretching them 13 per cent in diam, at —320° F. Arde-Portland, developers of the process, expect to be able to produce cases with strengths of 380,000 psi, within a year. B. J. Aleck (left), Arde-

new size 8



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There's great activity and optimism at Huntsville where NASA's mighty Saturn C-1 is being readied for flight tests this year.

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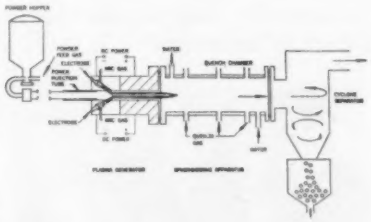
Technical Advances

continued

Portland research director, invented the process.

Hydraulic press, built by Verson Allsteel Press Co., exerts 63,000 tons of forming capacity. Said to be the world's most powerful press, it will be used in forming missile and aircraft components by Grumman Aircraft.

Flat billet method saves time and money in aluminum extrusion. AF developed technique uses a flat billet container instead of usual round container in conventional extrusion press. This method allowed an extrusion of 109,000 psi on the billet. By means of the container, an integrally stiffened panel of 7075 aluminum alloy, 18 in. wide, with web thickness of 0.037 in., having eight stiffeners, was extruded to a length of 25 ft.



Plasma arc generator is capable of spheroidizing refractory powders of 100 to 150 micron size with melting points in the 2100° C to 3200° C range. Bulk powder enters the phenolic plasma generator (left) where particles are fused at hyperthermal temp created by dual injection of arc-plasma gas streams. Quench chamber (center) solidifies molten spheroids, which are separated from effluent gas by cyclone separator (right). According to Plasmadyne, the system, with minor modifications, can be used as a chemical processing device for combining and reacting various gases, liquids and solids.

Market Planning

Machine Tool Outlook

It appears that the record FY62 defense budget will bring the long-awaited stimulus to the machine tool market.

DOD plans to spend a total of $100,000,000 for metal cutting and forming machines. About $60,000,000 of this will go directly to the aerospace industry.

Over 4500 machines figure in the overall DOD plan. Pentagon sources state that 1900 of these machines will be out-right purchases to add to the total inventory. The remainder will be replacements of existing machines.

In FY 61 DOD spent only $30.3 million for machine tools; $14 million of this was for purchases of new machines.

What Industry Looks For—Most of the leading machine tool makers look for the military to buy versatile, light, tape controlled machines with high accuracy. Technologies are changing so rapidly that the military can no longer buy only machines capable of doing one job.

Immune To High Budgets—The machine tool industry, however, has learned to live with budgets. They don't always mean more machine tools.

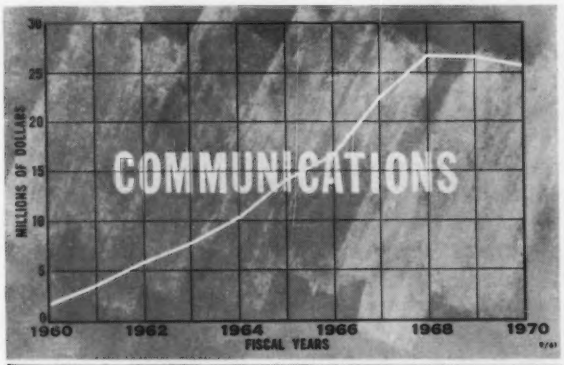
Despite the fact that the bulk of machines now cutting and shaping metal in aircraft and missile plants are of 1940 vintage, some manufacturers have a cautious outlook for FY 62. And there is an amazing scarcity of hard, long-range planning data available in the machine tool industry.

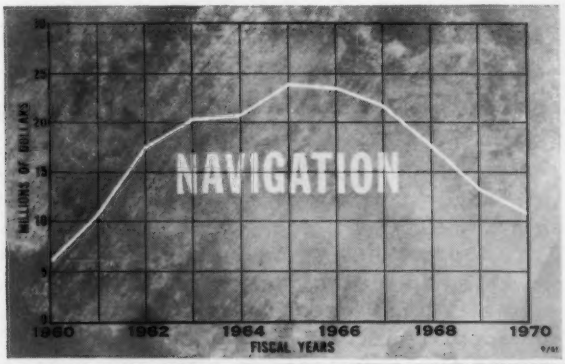
Price Must Be Right—The increased demands of versatility and automation in machine tools will require more research. Builders must realize that the tools they produce will have to be priced high enough to cover the added research expense. The more successful manufacturers have even found it necessary to set up separate plants for turning out aerospace machine tools. Sophisticated machines can not be turned out in the same facilities as the standard heavy machines. Costs will have to rise.

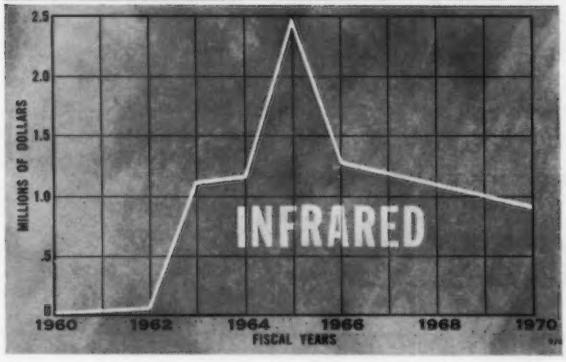
ARMY ELECTRONICS MARKET

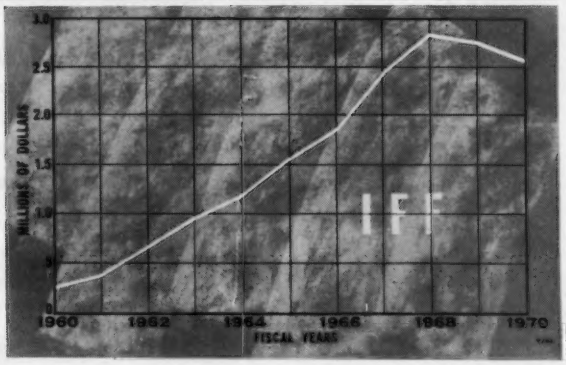
Trends For The Decade

Total electronic expenditures in the Army will peak in 1967 at more than $49 million. This contrasts with $9 million in 1960. By 1970 there will be a drop to $39 million. The decreasing need of heavy aircraft in Army is the cause of the drop.









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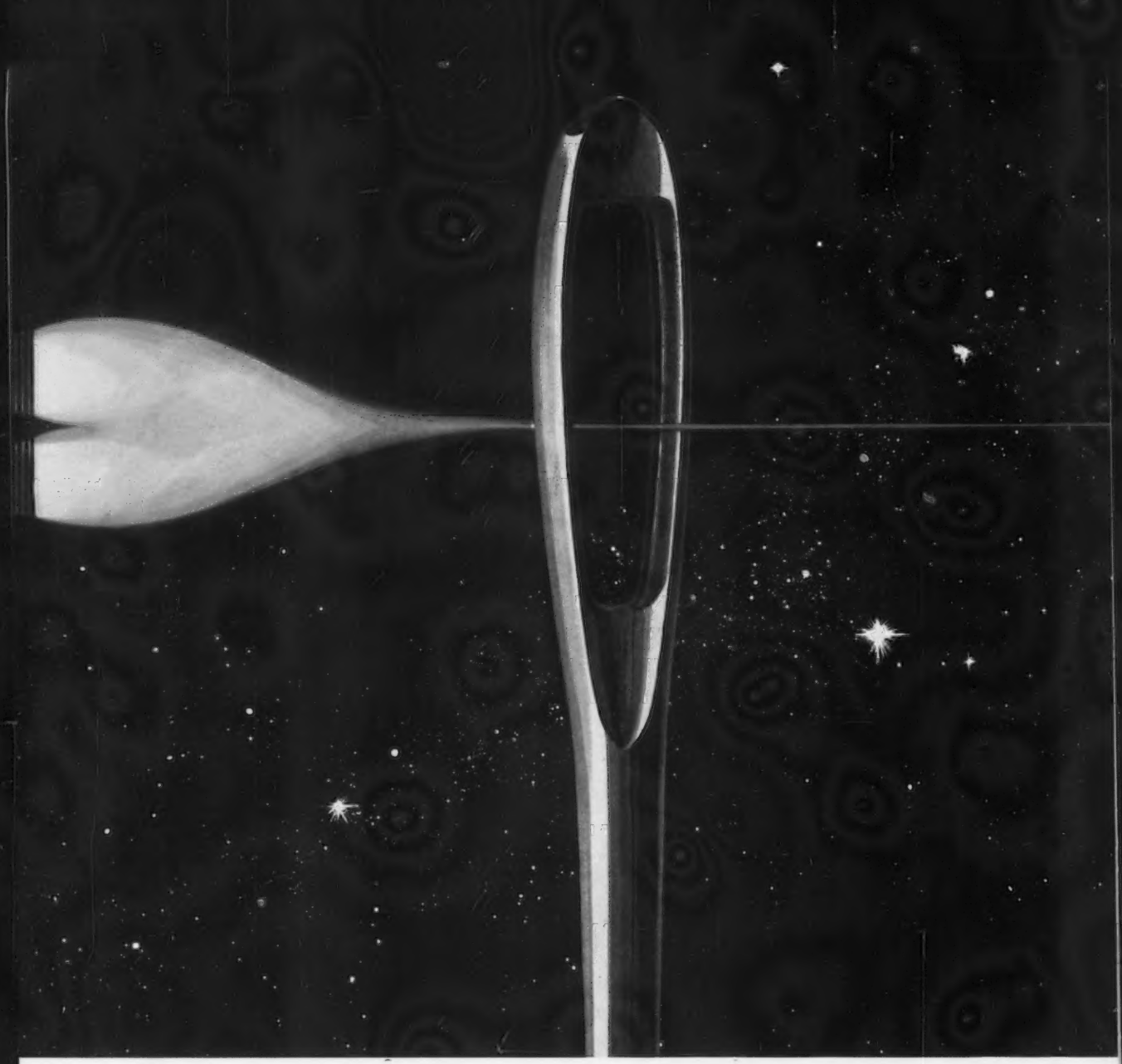
You get a steady, uninterrupted feed rate when you use Aircomatic wire . . . because helix is low and wire finish is mirror smooth.

Another plus value . . . the tensile strength of Aircomatic wire is uniform. And, finally, wear on guide train and contact tube is minor when they're handling Aircomatic wire.

For current price schedule on Aircomatic quality finish aluminum, stainless, copper and steel welding wires . . . call Airco or look in your Classified Telephone Directory under "Welding Equipment and Supplies" for your nearest Authorized Airco Distributor.

AIRCO®

AIR REDUCTION



Accurate enough to help put a missile through a needle's eye . . .

BENDIX NOZZLES FOR THRUST VECTOR CONTROL

Thrust vector controls to steer space vehicles with needle-threading accuracy are the subject of extensive research and development now being carried on at Bendix.

One technique being explored for Polaris and other missiles and spacecraft is secondary injection. The use of liquid or gas to deflect the exhaust jet provides a control system of great simplicity and reliability, while maintaining pinpoint accuracy.

Another Bendix control development—part of the Minuteman program—is movable nozzles. A pressure-tight, flexible seal permits nozzle swiveling to provide thrust vector changes, allowing course and/or attitude corrections.

Bendix PRODUCTS DIVISION South Bend, IND.

THE Bendix CORPORATION

Business Activity

NEW NON-PROFIT FOR ARMY RESEARCH

Army has awarded a $4,576,000 contract to the Research Analysis Corporation (RAC). This new, non-profit organization will perform the major portion of Army's Operations Research.

RAC will conduct studies in: Basic research, weapons systems evaluation, operations, information and controls systems, military economics and costing, strategic and management systems.

Initially, RAC will complete unfinished studies of the Johns Hopkins University Operations Research Office. The Johns Hopkins office was dissolved as a research organization in August.

Army's Operations Reseach Program in the past, has rested heavily upon mid-range planning and analysis. Recent studies pointed up important research needs in both short-range and long-range planning. These needs will require expanded efforts by the new research group.

RAC employs over 300 operations analysts and technical support personnel. The present administrative staff numbers 135. Mr. Frank A. Parker, Jr., RAC president, anticipates "doubling the size of RAC's scientific staff within the next five years." Mr. Parker was formerly Assistant Director of Defense Research and Engineering in the Office of the Sec. of Defense. He emphasized that RAC is strictly a scientific advisory organization. Conclusions of its studies take the form of findings and recommendations, intended to assist Army decision-makers.

RAC will report to Lt. Gen. Arthur G. Trudeau, Chief of Army Research and Development.

Objectives of Research — In a recent address, Gen. Trudeau described the broad outlines of current Army Research programs.

- Search for new energy sources, ranging from gas turbines to fuel cells, MHD generators, solar cells and nuclear propulsion. Gen. Trudeau said fuel cells are most promising for the 1970's.
- Research to bridge the gap between materials and solid state physics, to chain-link large molecules so that materials can be created as desired.
- Miniaturization in electronics, where it has already been found possible to develop the 2-D circuit with 2000 electronic components per cubic inch.
- Producing industrial diamonds out of carbon in an effort to learn more about the physics and chemistry of large synthetic crystals.
- Air-transportable nuclear power plant similar to one operating under the Greenland Ice Cap.
- Elastomer development programs for ground vehicles.
- New silicon carbide which has demonstrated a 35-fold increase in compressive strength over hot-pressed silicone carbide.

. . . More for Non-Profits

The MITRE Corporation, a not-for-profit organization supporting the Electronic Systems Div. (ESD) of AFSC, will take on an enlarged role in systems engineering. This is described as "the first major step in the transition to this new approach from the former concept of having a prime systems contractor."

Maj. Gen. Kenneth P. Bergquist, commander of ESD, in announcing the move, explained: "Command and control systems are evolutionary, must grow with the using organization, and must be designed to provide appropriate interface with each other as well as with the weapons systems; therefore, military conceptual planning and design control is essential."

"Our system design and management responsibility, the amount of trained personnel resources immediately available, and the nature of the task necessitates obtaining technical support from a not-for-profit organization."

MITRE will be responsible for advanced systems analysis and planning, research, experimentation, initial system engineering, technical direction and intersystem engineering in a relationship similar to the one between the Aerospace Corp. and the AF Space Systems Div.

More on the not-for-profits on page 34.

Electronics In West

One fourth of total electronics sales and employment in the U. S. is concentrated in the eleven western states. Employment in western companies has reached 215,000 or 24.6 per cent of the total U. S. electronic manufacturing employment. Western sales for 1961 should climb to $2.8-billion or 24.9 per cent of the national total according to the Western Electronic Manufacturers Association (WEMA).

Exports Increase

Aerospace Industries Association survey of four U. S. manufacturers of civil utility aircraft indicates an upswing in exports. The

four firms exported 874 aircraft valued at $16,694,100 during the first six months of 1961. This is an increase of 23 per cent in dollar value and a 13 per cent gain in unit number for the same period in 1960. All aircraft has an empty weight of 6000 lb and under, and do not include commercial transports.

The four firms estimate that utility aircraft exports will reach $30-million in 1961.

Bi-Service Fighter

Air Force and Navy have taken the first step toward development of a tactical fighter aircraft (TFX). Studies have indicated that it is feasible to build a fighter that can operate from both carriers or small remote airfields. A joint tactical fighter program will save the large development costs of two separate aircraft. TFX program will be managed by AF with full Navy participation. Contract will be awarded in early 1962.

General Dynamics and Grumman will pool efforts in the TFX design competition.

Ford Motor Co. plans to purchase the assets of Philco Corp. In announcing the move, Mr. Henry Ford II said: "Ford Motor Company's purpose in purchasing Philco Corp. is to broaden its operations, to provide entry into new fields and to make possible a fuller participation by our company in the national defense and space effort." The present Philco organization, including its personnel and facilities, will become a wholly owned subsidiary of Ford, which plans to continue the business activities of Philco without interruption.

Michoud Ordnance Plant, government-owned plant near New Orleans, La., has been selected by NASA for fabrication of large launch vehicle stages. Contractor to operate $50-million plant has not been selected yet. Plant is expected to begin operations in about a year.

Lockheed-Georgia reports savings of $1.5-million through value analysis after three month operations. Many cost-cutting ideas carried an added bonus of precious weight-saving in the aircraft, besides reducing production time and costs. Lockheed-Georgia produces C-130 and C-140 aircraft, and is developing the C-141 cargo transport.

Hi-Shear Corp. has completed a new ordnance facility for the development and manufacture of ordnance devices such as separation nuts, pin pullers, tension rod and cable disconnects.

Hewlett-Packard Co. will expand its European operations. A plant will be built in Boeblingen, Germany, and a plant in Bedford, England, will be leased, in addition to the recently announced new plant in Loveland, Colorado. Foreign sales in 1960 increased 60 per cent over 1959, and are continuing to gain this year, particularly in European countries.

MANAGEMENT QUOTES

Milo McCammon, Eclipse-Pioneer Div., Bendix: " . . . we need total improvement, across the board . . . management, supervision, salaried and hourly improvement. We have taken many new steps to develop the skills and efficiencies of our management team, and today we are engaged in more management developments than ever before."

Dr. Arnold O. Beckman, pres., Beckman Instruments, Inc.: "For effective marketing, we must regard ourselves as people with the capabilities to solve problems, not just people with attractive hardware to sell. We must do a better job of harnessing our problem-solving resources to the needs of the customer."

Elvis J. Stahr, Jr., Sec., Army: "He (President Kennedy) emphasized the need to approach the problem of budgeting by determining military needs before calculating the costs . . . by making the budget fit requirements instead of bending needs to conform to the budget. . . . The concept of putting the dollar sign where it belongs has a corollary. . . . the obligation to squeeze the most out of every dollar spent . . . I believe we should give the highest priority to getting the absolute maximum out of the manpower alloted to us."

Robert C. Sprague, chairman, Electronics Industries Association's Imports Committee: " . . . our exports last year were more than three times the dollar volume of imports . . . $483.4-million compared with $148.7-million. But the rate of increase has been far greater in imports, and by far the greatest rise has been in shipments from Japan which has a wage advantage of about 5 to 1 over American producers. Japanese electronic shipments to the U. S. have increased from $230,000 in 1955 to $71.4-million in 1960 and are still rising."

Thomas P. Leddy, executive v. p., Elgin Watch: " . . . we may establish a facility, or tie up with a manufacturer who has a plant, in one of the NATO countries. (They) are increasingly buying components and missiles, from plants near their headquarters."

MAJOR CONTRACTS

CONTRACTOR	VALUE (Millions)	FROM	PROJECT	PRODUCT/SERVICE
Adler Electronics.	1.2	Army	TSC-18	Air-transportable communications systems
Admiral Corp.....	2.0	Navy		Airborne friend or foe identification equipment
Aerojet General..	1.4	A F		Produce liquid propellant rocket sled system and components
	6.3	AEC-NASA	Nerva	First phase development of nuclear rocket engine. Westinghouse will do nuclear work
Air Products.....	1.3	A F		Operate and maintain liquid oxygen and nitrogen plants
Astro-Science....	1.1		B-58 Dewline	Pod handling systems Mobile ground support systems
Guy Atkinson Co.	2.5	Navy	Advent	Convert ship for satellite communications terminal
Avco Corp.....	11.2	Navy	Polaris	Major portion for Polaris arming and fuzing
	28.5	A F	FPS-26	Height finder radar
	1.4	Navy	Hydrofoil	Prototype hydrofoil amphibian
Baldwir-Lima-Hamilton.....	1.0	A F		Aircraft weight distribution computer planner
Bendix Corp.....	10.5	Army	Pershing	Guidance components
	8.0	A F		Rocket borne communication system
	1.3	A F		Repair kits for magnetos, distributors and harness
	1.5	A F	GPA-27A	Produce six radar sets
Boeing Co.....	5.0	A F	B-52	Engineering flight testing
	18.3	A F	B-52	Cyclic testing of G and H models
Chrysler Corp....	.9	NASA	Saturn	Reliability testing of components, and ground enipment
Collins Radio....	1.6	A F	KC-135, B-52	Airborne transceivers
Consolidated Electrodynamics	1.9	Navy		Pressure detectors, hydrophones, depth compensators
Cubic Corp.....	1.7	A F		Digital data systems
Douglas Aircraft Co.....	10.0	A F	B-47	Inspection and repair FY 62
	2.9	A F		Launch support, Patrick AFB
Drexel Dynamics.	1.2	Navy		Underseas mine equipment
Dynamics Corp. of America.....	7.0			Missiles, radar and computing systems, long-range tracking radar, gyros
FMC Corp.....	1.2	Navy	Hydrofoil	Prototype hydrofoil amphibian
Ferguson, H. K...	6.0	AEC		Construct production reactor at Oak Ridge
Garrett Corp.....	.8	Navy	P3V, W2F,	Air turbine starters
	6.1	A F		Spares and modification kits
General Dynamics	12.9	A F	B-58	Category 1 flight tests
	128.8	Navy	Polaris	Produce three nuclear subs
General Electric..	1.1	A F	Samos II	R & D
	9.0	Thiokol	Minuteman	Rocket case production
	8.0	A F		Support engineering on YJ-93-GE-3 engine
	15.3	Northrop	Skybolt	Development of guidance computer
	1.0	Navy		Radio telescope aiming reference system design
	1.9	A F		Radar sets
	1.5	Army	Vulcan	Tooling for production of 20-mm gun
	1.6	Army	Vulcan	Parts and hydraulic drives
General Motors..	20.7	A F	P3V, W2F	Tech data and support equipment and engines
Gilfillan Brothers.	3.5	A F		Update landing-control radar
	1.5	A F		Kits for modifying radar training sets
Goodrich, B. F....	1.2	A F	F-105	Spare tires
	2.6	A F	F-84 Century series	Tires and tubes plus wheels and brakes for cargo aircraft
Goodyear Tire and Rubber.....	2.6			Tires, tubes, wheels, brakes, fuel cells for all services
	1.5	Navy	Asroc	Produce missile launched depth charges
Hallicrafters Co..	3.0	A F		Electronic penetration system for bombers
Hayes Corp.....	4.0	A F	C-118	Inspection and repairs
HRB-Singer.....	2.4	Army	UAS-4	Ground support test equipment, repair and spare parts for infrared detection systems
Hughes Aircraft Co.....	1.8	Navy		Infrared temp detector and cryostat
	1.6	A F		Missile shipping and storage cases
Hupp Corp.....	3.7	A F	F-105	Pylong and bomb racks
Hurletron, Inc....	1.8	RCA	Atlas	Electronic timing devices
IBM.....	3.2	NASA		Computer rental FY-62
IT&T.....	7.8	Navy		Tactical air navigation radio sets
Kaman Aircraft...	3.6	A F	H-43B	Production of Huskie helicopters
Kittell-Lacy.....	1.6	A F		Noise suppressor for aircraft ground run-up
LFE Electronics..	3.7	A F	F-105D	APN-131 self-contained Doppler navigation equipment
Ling-Temco-Vought.....	1.5	A F	C-133	Modification and reconditioning
Lockheed Aircraft	7.3	A F		Maintenance of C-121, C-118, C-137, C-140, C-131, U-4 and H-13J
	2.7	A F	C-118	Reconditioning
Magnavox Co....	40.0			Radar guidance, communications, and detection systems
Martin Co.....	1.0	A F	Matador, Mace	Maintenance
	1.5	A F	GAM-83	Produce 424 trainer missiles
	1.1	A F	Matador, Mace	Storage and distribution
	70.7	Army	Pershing	Tests and production
	16.9	Army		Design floating nuclear power plant
	3.1	Army	Pershing	Production
Melpar, Inc.....	1.0	A F	GAM83A/B	Seven missile trainers
Minneapolis-Honeywell Regulator Co....	2.0	General Dynamics	Atlas	Rate gyros for guidance systems
	1.2	NASA	Saturn	Adapt Centaur guidance for Saturn
North American Aviation.....	1.8	A F		Acquire and install facilities under Machine Tool Modernization Program
	7.1	A F	F-100	Modification kits, launcher assemblies and trainer kits
Philco Corp.....	4.7	Army		Communications system
Polarad Electronics.....	4.0	Navy	URC-32	Transceivers
Pratt & Whitney..	69.9	Navy	A2F-1	Production and development of J52 jet engines
RCA.....	1.4	A F		Flight controls
Radiation, Inc....	1.0	NASA	Nimbus	PCM telemetry ground equipment
	1.6	A F		High-output transmitters and power supplies for Haystack facility
Raytheon Co.....	1.8	Navy	Polaris	Electronic portion of guidance for advanced Polaris
Reeves Instrument.....	4.4	A F		Radar bomb scoring centrals
Rohr Aircraft....	1.0	Lockheed	C-141	Produce nacelle pylons for first five jet cargo transport
Ryan Electronics.	2.0	Hughes	Surveyor	Produce radar altimeter and sensors for lunar soft landing vehicle
	8.3	Navy		Airborne C-W Doppler navigation systems, spares and support
Sperry Gyroscope	6.5	A F		Amplitron tubes and radar work
	5.5	A F		Installation and testing of long range search radars
Sylvania Electric.	2.1	A F		Engineering and production of receiving equipment
Systems Development....	28.1	A F	SAGE	Services and supplies for training programs on Semi-Automatic Ground Environment system
Teletype Corp....	1.6	FAA		Automatic send-receive sets
Textron, Inc.....	10.0	NAA		Airborne radar antennas
Westinghouse....	6.3	Aerojet	Nerva	Nuclear portion of Nerva rocket engine development

Man-In-Space . . . Management Crisis Coming

- *To meet demands and challenges of the sixties military leaders and backers call for better management.*
- *Russia bent on military space supremacy.*
- *NASA "conservative to an extreme."*

. . . will needed changes come? . . .

What's wrong with our man-in-space program? A lot is wrong! And, it's serious!

Those who reduce the problem to one of big boosters are deluding themselves. They say, "we are ahead in space science, the Russians just happen to have bigger launch vehicles." This is not true.

The man-in-space program lacks purpose, lacks leadership, and lacks strong intermediate programs directed at plugging technological gaps.

These charges were hammered home hard at the recent Air Force Association Convention in Philadelphia, by a panel of space experts during a symposium on "Space and National Security."

A Management Problem—General Bernard Schriever, Commander Air Force Systems Command, summed up all our man-in-space difficulties with this statement: "The problem is one of management."

Congressman Emilio Daddario (D-Conn.) added, ". . . we are bound by the ingredients of time, money, manpower, and materiel. . . . How well we manage them will determine our success."

Gen. Schriever indicated, however, that some drastic management changes will manifest themselves in the next 90 to 120 days. These are expected to unify our man-in-space effort for the important drive through the 60's.

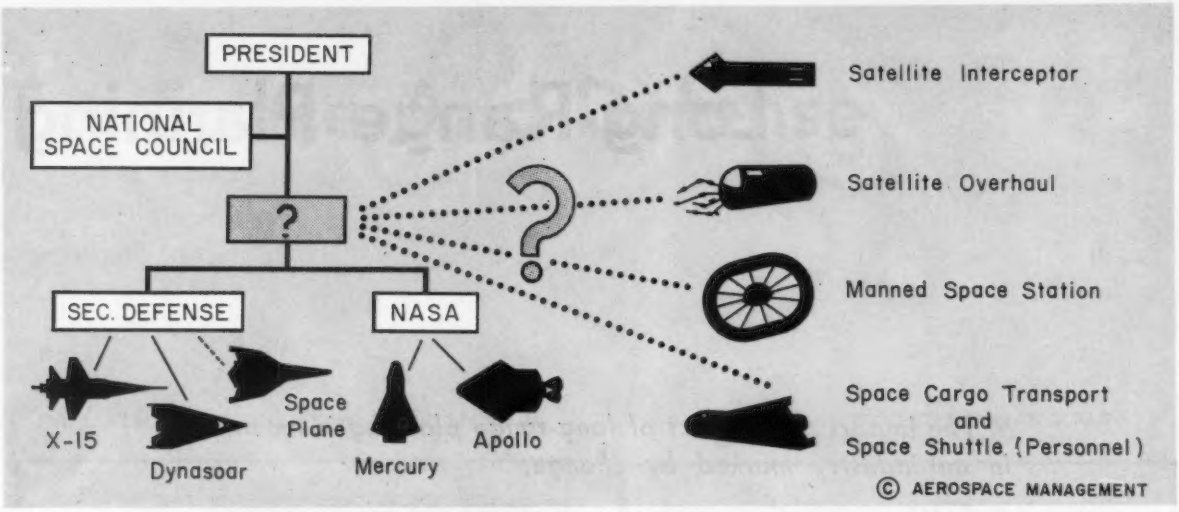
The management changes are expected to put the military, in general, and Air Force, in particular, in a very strong policy position in the joint civilian-military effort.

Military Wants In—Criticism of late has been running heavy that U. S. refuses to recognize the military value of a man-in-space program. Schriever says, "we need to recognize that there is no inherent difference between basic military and non-military space techniques."

Is the military entry into space important? Dr. Walter R. Dornberger, former German rocket kingpin, and now vice president of Bell Aerosystems Co., speaking of Russia's intentions says, "in spite of all the propaganda to the contrary . . . Russian political and military strategists are aiming at military superiority in space. . . . I see today no unsolved fundamental technical problem preventing the Communists from achieving such a goal within the next ten years. . . . To counteract this threat (world domination through space) . . . is the greatest challenge for our country."

"How will we organize, how support financially, how best plan, how manage our space effort? What are our goals? Where should we put our emphasis? These are some vital questions for which we better have answers today. . . . If there is ever any doubt about how much money is available, we should put our money on the military systems."

Dornberger added that it won't make much difference "if we send a three-man spacecraft to the Moon in the next decade (Apollo) . . . when coming back they find that the



Although President Kennedy has stirred the Space Council to action, he alone must solve the mounting conflicts between NASA and DOD. Some think effective management of the national space effort demands daily attention. They see a super cabinet post for Space Research and Exploration as a possible solution.

free world does not exist anymore."

We may in fact do just that.

Conservative To An Extreme—Congressman Daddario said at the convention that Air Force "offers the most valuable talents" for putting man in space. Speaking of the civilian space establishment he added, "in NASA we have a civilian agency with exceedingly great opportunities to assist in this effort."

Then adding more fuel to the management fire Daddario asserted: "Research and development skills are of the highest order and only the call and the direction to be of service is awaited."

Military proponents are not reluctant to indicate that the management problem is within NASA. Daddario observed, "civilian scientists . . . have appeared to me to be cautious to an extreme. They wish to move slowly from step to step to reach their goal without the necessary urgency. . . . Air Force wants to recognize a specific terminal goal of the landing. . . . My concern is to move together on these two paths."

NASA Strengthens Management—If the interfaces of NASA and Air Force move closer together on man-in-space as indicated, NASA's almost exclusive role will be hurt. To strengthen its own management position, NASA made an important move last month. After several years of discussing Apollo and the man on the moon program, NASA appointed a manager to coordinate its man-in-space activity. He is D. Brainerd Holmes, now with RCA's Major Defense Systems Div. He will take over Apollo management on November 1. His management group is expected to number 300.

Early this month (October 9) NASA will recieve bids on the Apollo spacecraft. This is its most ambitious man-in-space program. That's why time could run out on NASA in the 60's. Apollo may not be ambitious enough.

Unfilled Missions—The military sees a need for manned moon bases, intercepting and neutralizing hostile spacecraft, repair and maintenance of space stations. NASA's plans do not yet call for such an extensive space program.

When the military convinces enough people it has a mission in a certain environment, history shows that it moves in and dominates the area. This could happen with man-in-space.

Trevor Gardner, Chairman of the Board of Hycon Mfg. and one-time Asst. Sec. Air Force for R&D, points with alarm to Russia's capability for putting huge, manned payloads in orbit. "We had no means then (August 19, 1960, when Russia launched a 5 ton spacecraft) nor do we have any capability now to neutralize, capture, or destroy such spacecraft if they are hostile. Nor is any such capability under urgent development."

Cabinet Post?—It is obvious "despite propaganda to the contrary" that NASA and Air Force have mounting differences over man-in-space, and the missions to be performed in space. At present there is no real authority to resolve these differences but the President. Space problems are too urgently in need of solution and too demanding of time for the Chief Executive to be the only recourse.

Many in the past have called for a cabinet post to regulate and centralize all space research and exploration. The growing capability of Russia to mount a military space force, our own modest achievements in space, and the mounting NASA-Military differences are moving us in the direction of a super adviser or cabinet post for space in the sixties.

Long-Range Planning

- *The import and impact of long-range planning is mounting in an industry marked by change.*
- *Setting objectives and choosing alternatives is management's most critical task.*

by Herbert K. Wiess, Manager
Military Systems Planning & Operations Research
Aeronutronic Div., Ford Motor Co.

Long-range planning is important in all industries. But, in the defense industry it is critical. Attention to it cannot insure success. But, ignoring it is almost certain to bring failure.

For the past decade, annual expenditures for national security have approximated ten per cent of the gross national product. This level has been equaled only three times in the past, and never before in time of peace. Expenditures are not likely to be substantially decreased in the near future.

For government, the critical problem is in allocating these expenditures among current weapon systems, new weapon systems, and research which will make both obsolete. For industry, the continuous critical problem is to anticipate the changes in weapon systems and to deploy the resources of industry to meet new demands as they arise.

Six Major Changes—Since 1941 the United States military program has undergone at least six revolutionary changes:

- Adapting to nuclear weapons.
- Adapting to intercontinental strategic bombardment aircraft.
- Adapting to supersonic manned flight.
- Defense of the continental United States against massive bomber attack.
- Development of intercontinental and submarine-launched ballistic missiles.
- Defense against the ballistic missile, limited wars, and space flight.

The crises associated with these changes (all of which involve technological obsolescence of current systems) have accelerated the development of methodology for long-range planning to guide the most efficient deployment of resources. But even the best methods still fall short of satisfying the need.

The breadth of the planning process is indicated by the following typical functions performed in planning:

- Estimate areas of probable future importance.
- Interpret effects of new technology.
- Guide growth of a capability that will be consistent with

For Space And Defense

FIG. 1. PERCENTAGE BREAKDOWN OF DOD SPENDING

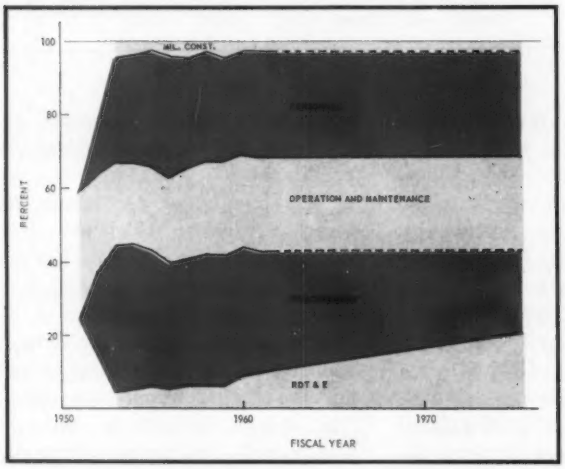
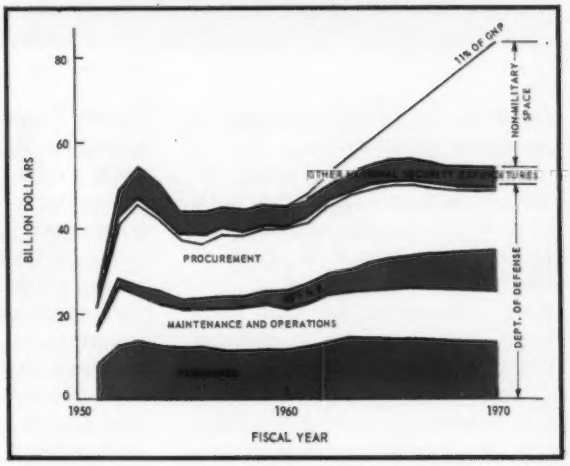


FIG. 2. PAST AND PROJECTED DOLLAR OUTLAY
National Security and Non-military space.



changing technology and needs.

- Attempt to match what is technologically possible with what may be required.
- Assist development of a corporate structure consistent with long-term sales objectives.

Purpose of Planning—The purpose of such planning, in the context of a major defense system contractor, is:

(1) To provide information for decisions now to achieve future success.

(2) To identify plausible future systems choices.

(3) To identify major problem areas in meeting future system requirements.

(4) To indicate desirable areas for current research and preliminary development.

(5) To recommend appropriate allocation of corporate resources.

The Forecast—To achieve these objectives the planner needs to have some idea of how the "market" and the economic environment are changing. He needs to understand what their future characteristics are likely to be, i.e., "forecasts." A "forecast" is, however, only a small part of the planning process.

The development of a forecast can take many forms. In the short run, it may simply be the consolidation and analysis of the reports by customer representatives on what potential customers are planning to buy within the next few months. This short-term consensus, although essential to fix the current status of the market, is of little help in deploying resources in preparation for a market whose characteristics will almost certainly change drastically within five years.

A medium-term extrapolation is possible by constructing trends. In the defense market, for example, careful reading of the published budget information makes it possible to establish the categories and sub-categories in which funds are being expended, and to extrapolate these trends into the future. The common assumption for such trend forecasts is that "present trends will continue and there will be no major change in the international situation." These trends, supplemented by examination of statements of military representatives regarding military requirements, can assist in

FIG. 3. SPACE SPENDING—MILITARY vs. NASA

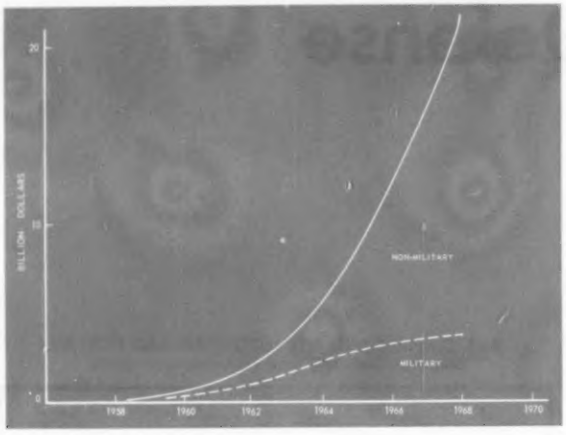
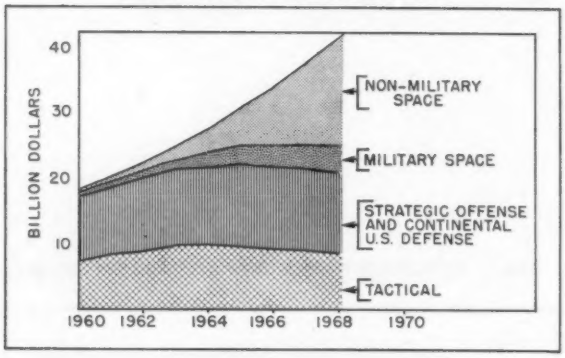


FIG. 4. THE LONG RANGE EXPENDITURES BY FUNCTION
Procurement, Production, RDT&E



identifying areas and sub-areas of increasing importance.

In the long run, however, the new products and capabilities made possible by research will introduce factors which cannot be predicted by trends. Interpretation of research discoveries for their long-term implications is an essential part of a long-term plan.

In preparing estimates of trends it is necessary to make assumptions regarding external events which can be decisive in effect. Alternative forecasts are then made of each set of assumptions. Table 1 shows such a possible set of assumptions.

The "most probable" set of events is listed first. For this case the planner might attempt to estimate the gross military and space market by projecting government expenditures. The probable continuing intense competition with the Communist World economically, militarily, and scientifically suggests total federal expenditures for space and national security is growing to about 11 percent of the GNP, with GNP increasing at about 4 percent per year because of increasing population and increasing productivity per worker.

Shaping a Forecast—Of the military budget, the fraction devoted to personnel has varied in the past 25 years from a low of 20 to 25 percent in wartime (when procurement of equipment to replace combat losses was proportionately higher) to 30 percent when international tensions were low and there was no arms race. Operations and maintenance consume a comparable portion of the funds. An increasing fraction of the remainder has gone to research, development, test and evaluation, as opposed to procurement and production (Fig. 1.).

Fitting these estimates and projections of the cost of contemplated space programs under the total expenditure limit leads to an estimate by categories, as shown in Fig. 2. Continuation of the process provides estimates by function, i.e., space, strategic, air defense and tactical systems, and by product type, i.e., aircraft, missiles, electronics.

Fig. 3 shows an estimate of the division of space expenditures between military and non-military applications, assuming that non-military funds will carry the expenses of new booster development and the manned lunar expeditions; and Fig. 4 shows this estimate superimposed on estimated expenditures for RDT&E and procurement of non-space strategic and tactical weapon systems. The allocation of categories is somewhat arbitrary. Practical application begins at the next lower level of detail. This sort of estimate is, of course, highly tentative and subject to gross errors, depending on external events. It should not be taken seriously unless specific probable programs are shown to add up to equivalent expenditures.

To some extent such charts reveal the extent to which new markets are displacing the old. For example, the increasing percentage of military expenditures devoted to missiles at the expense of aircraft could be anticipated by this method, and the similar inroads on space-type systems on both is apparent. The rapidly increasing electronic content of all weapon systems can be thus illuminated. The method, applied in finer detail, provides illumination on the relative growth of market components such as radar versus infrared guidance systems, ground support equipment versus delivery vehicles, and so on.

This approach suffers from vulnerability to critical events which it cannot anticipate. These events, even though they may not be as drastic as those described in Table I, which would change the picture completely, may still be sufficiently powerful to affect the character of the programs which make up the gross expenditures.

Soviet Achievements—The public announcements of technical achievements by the Communist nations, for example, have had very strong influences on our own program. In each case, although there were many people within the military services and industry who ex-

FIG. 5. WEAPON SYSTEM SALES
A space program with no production is usually short lived and smaller in dollar volume than a production program

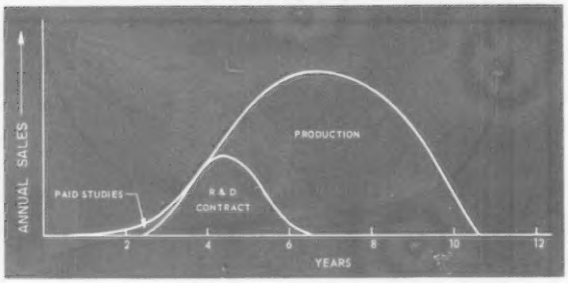


TABLE I

ALTERNATIVE ASSUMPTIONS AFFECTING MARKETS

Possible Assumptions	Effect on Markets
1. No Hot War—No Arms Control.	Markets as extrapolated, with changes emphasizing space. More limited war R&D. More limited war procurement.
2. Limited War.	Heavy procurement of weapons already developed. Much more limited war R&D. Less space money. ICBM & AICBM continued with urgency.
3. No Hot War—Arms Control.	Reduce armed force size. Stop nuclear testing permanently, or continue for peaceful uses under international inspection. Reduce ICBM procurement. Reduce conventional weapons procurement. Emphasize peaceful space. Continue weapons R&D at reduced rate. Develop devices for monitoring arms control.
4. All Cases.	Rapidly expanding industrial and military electronics market.

pected these technical "milestones" to be achieved, the full impact was not felt until they had been demonstrated to the public beyond all doubt. Table II, prepared in October 1960, shows such a list containing both past and predicted events. It will be noted that not only did two of those anticipated last October occur, but they occurred in the order predicted.

The criterion for establishing a date is the general acceptance by the American public that the event has taken place. The Soviet nuclear submarine, for example, is the subject of many rumors, most of which allege that it exists in small numbers. These rumors appear to have had only a moderate effect on public opinion. When, however, the Soviets make a public display of a nuclear-powered, missile-launching submarine, general reaction to the display may be completely out of proportion to its military worth. Yet it may serve as a trigger to implement antisubmarine programs previously known to be desirable, but inadequately funded. The unequivocable demonstration of a successful Soviet Anti-ICBM would have even greater repercussions. So wide in fact that you would have to provide your own estimate as to the effect of such a demonstration.

Phasing of Weapons—Another consideration in planning is the phasing and relative importance of weapon systems. The need for new weapon systems is a reflection both of international tensions and national policy. To a substantial extent this need can be estimated in the long run from open sources to the degree needed for planning. There are numerous fine unclassified documents on national policy, sponsored by Congressional Committees, which provide the necessary background. The present emphasis on limited war weapons, for example, is a culmination of a trend which was perceptible a number of years ago. It could reasonably have formed a part of the contingency component of a long-range plan prepared at that time. Within the framework of service missions roughly estimated in this fashion, it is possible to estimate from current development and procurement status the approximate time at which new weapons will be needed to replace those now under development. These estimates can be used to guide the scheduling of internal systems studies.

A typical phasing chart for planning to meet continuing needs would include the following entries:

(1). Function (strategic bombardment, Army close support, tactical communications, etc.).
(2). Service (Air Force, Army, Navy, Marines).
(3). Most advanced system under development or procurement to satisfy the specified mission.
(4). Estimated date at which new system to replace system in item 3 must be operational.
(5). Estimated date for initiation of development program of new system to meet date estimated in item 4.

A set of charts of this type for each major mission category (strategic, tactical, air defense) gives a framework into which current information on sponsored studies of new systems can be fitted. It also provides an independent estimate of when a system is likely to be funded.

Operations analysis studies considering cost and effectiveness provide a means for indication which systems are most needed, when the state-of-the-art will obsolesce current systems, which solution should be selected within a finite budget,

TABLE II

COMMUNIST TECHNICAL MILESTONES

A-BOMB	1949
H-BOMB	1953
BISON FLY-BY	1954
H-BOMB AIRDROP	1955
SS INTERCEPTOR FLY-BY	1956
ICBM	1957
SPUTNIK I	1957
MOON-SHOT	1959
MAN IN ORBIT	1961
SUPERSONIC BOMBER FLY-BY	1961
100-MEGATON WARHEAD	
NUCLEAR SUB	
CHINESE A-BOMB, H-BOMB	
MANNED LUNAR FLIGHT	
ANTI-ICBM DEMONSTRATION	
MANNED LUNAR LANDING	
MAN ON MARS/VENUS	

FIG. 6. PROGRAM MORTALITY RATE AND CAUSE

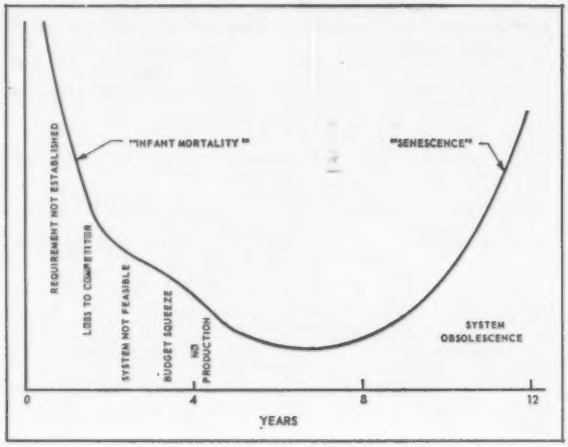
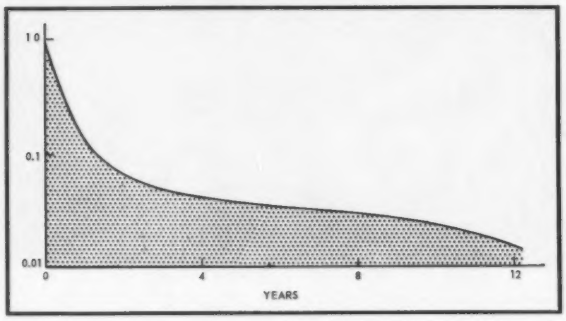


FIG. 7. LIFE PROBABILITY FOR NEW CONCEPT On Day Contract is Let.



and the probable magnitude of the procurement.

The Wake of Invention — The most difficult area to forecast, of course, is what will happen in the wake of new scientific discoveries. The projections of the specialists tend to be too conservative, while the projections of non-specialists are not authoritative. Here the only solution appears to be to list new discoveries which have application to your product areas, and to work out the consequences of possible successful application of the research results jointly with those skilled in the technology. Since so many technologies are involved in each class of weapon system, and since a major advance in any one can lead to a critical over-all improvement, this estimate of what may be technologically possible may be of greater importance than an estimate of requirements made without regard for what is possible.

The interaction of changing technology and the "single-customer" nature of the military market with the internal structure of industry creates unique problems in planning. Fig. 5 shows the well-known expenditure pattern associated with a typical weapon system. A space program with no production would trace only the study and R&D portion of the curve.

On the industrial side of the transfer of funds, military expenditures generate industrial sales which provide industry with resources to be applied to in-house research and development and new concept generation to meet future requirements. A cumulative net profit may not be associated with a particular program for some time after its initiation because of expenses incurred in initial competitions.

Mortality Rate—The mortality of new concepts is high, however. Fig. 6 shows an estimate of this mortality rate (analagous to the actuarial function "force of mortality"). On the day a contract is obtained to study a new system, the probability that the program will "live" to various ages is roughly as shown in Fig. 7. As each "milestone" is successfully passed, however, the probability that the program will live for another year increases (Fig. 8). Finally old age sets in, the system is outdistanced by the state of the art, and a new system takes over.

In planning corporate growth, all of these phases must be considered. Too many programs which die in infancy, before their initial costs have been recovered, will communicate their morbidity to the corporate body. Each program undertaken must at its inception show a positive expectation of profit, considering all of the possible "causes of death" noted above. To aid in insuring this positive expectation is the job of planning.

Employment Planning—For the past 70 years the ratio of total workers to scientists and engineers in the labor force has decreased at a constant per cent per year (Fig. 9). In 1900 one worker out of 800 was a scientist or engineer. Today the ratio is one out of 80. The trend in the defense industry, typified by data for the aircraft and parts industry, is far more drastic. Within seven years the ratio has dropped from 15 to one to almost five to one (Fig. 10).

Will these trends continue? If there is no hot war, competition between the Free and the Communist Worlds will continue on both military and economic fronts. The Soviet emphasis on enginering training is well known. It is not likely that the pressures increasing technological content of the total industrial effort will soon be relieved.

Accepting the trends of Fig. 10 at their face value, a need for almost a million and a half engineers and scientists in 1970 is forecast, compared with about 850,000 engineers employed in the U. S. in 1959, with an additional million required in the 1970 to 1980 decade. At present the U. S. graduates about 38,000 engineers a year, a rate which is optimistically extrapolated to some 70,000 a year in 1970. The total supply thus nearly matches the esti-

FIG. 8. LIFE PROBABILITY OF EXISTING PROGRAMS

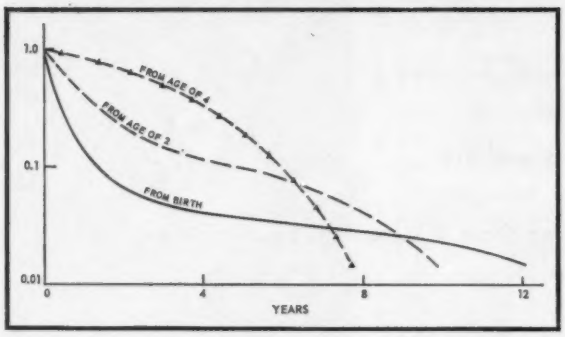
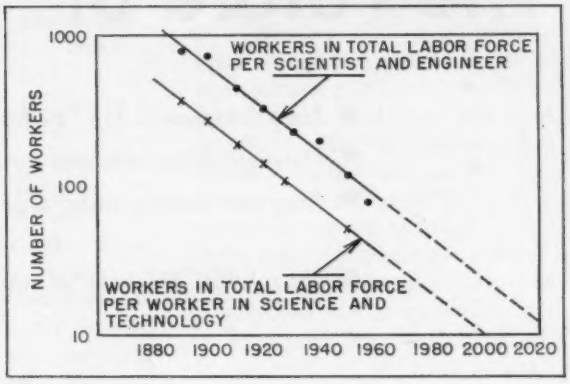


FIG. 9. INCREASE IN TECHNICAL PERSONNEL


1000
100
10
NUMBER OF WORKERS
WORKERS IN TOTAL LABOR FORCE PER SCIENTIST AND ENGINEER
WORKERS IN TOTAL LABOR FORCE PER WORKER IN SCIENCE AND TECHNOLOGY
1880 1900 1920 1940 1960 1980 2000 2020

mated demand. However, this excludes graduate engineers who are diverted to non-engineering activities including management, sales, etc., and does not consider the attrition of the engineering force as a whole by retirement and death. Also of major importance is the obsolescence of engineering knowledge gained while in school which tends to reduce the productive life of the scientist and engineer who does not continue his training after graduation, supplementing his work.

Narrowing Gap — The consequences of these trends and the possible mismatch of supply and demand may well be reflected in the continued increasing cost of engineering hours. Starting monthly salaries of engineers with B.S. degrees are shown in Fig. 11, as are mean salaries for engineers with 10 years of experience. The growth of both and the dangerous narrowing of the gap between them are apparent. These salaries have not been corrected for the changing "value of the dollar," which is shown separately, since the progressive increase in salaries is much smoother than the fluctuation in the Consumer Price Index.

This all means that the planning process is analogous to the military "estimate of the situation." The planner attempts to identify those alternatives open to his company in terms of its objectives. He also attempts to identify those alternative courses which may be taken by the flow of events external to the corporation. Considering the interaction between each set of alternatives, he evolves a series of recommended actions for his company which, in view of the uncertain future, are most likely to assist it to achieve its objectives.

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FIG. 10. WORKERS PER SCIENTIST & ENGINEER

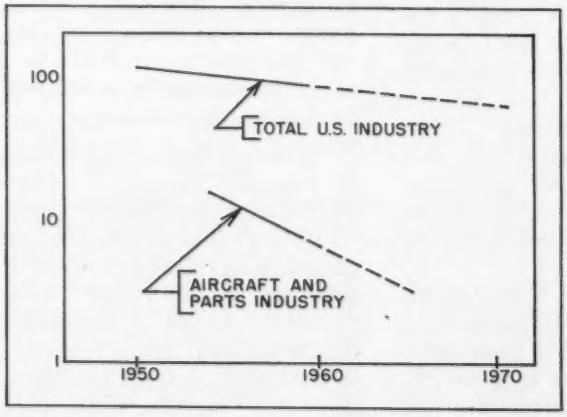
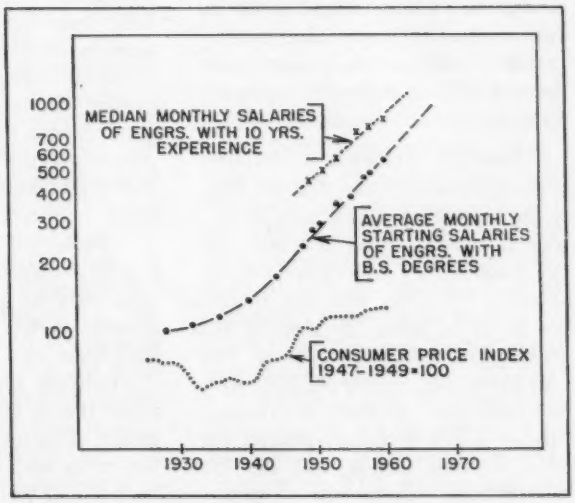


FIG. 11. THE NARROWING SALARY GAP



The Future of "Non-profits"

- *They function in the "twilight zone" between private industry and Air Force.*
- *They are often resented by industry.*
- *They are coming under Congressional fire.*
- *They fulfill the role of managing from a detached point of view.*

. . . they are here to stay

by Phillip Geddes,
West Coast Editor

In fiscal 1962 a total of $106.9 million will be distributed among five major non-profit organizations —$34.8 million going to Space Technology Laboratories (STL), and $30.2 million going to Aerospace Corporation. Lincoln Lab will handle $15.3 million, Mitre $15.0 million and Rand $11.6. While the sum of money consumed in the non-profit organizations is large, if the Air Force and in turn Congress are convinced that the investment is necessary the "not-for-profits" will become a permanent part of our free-enterprise aerospace system.

Industry Criticism — Industry management concedes that the large non-profit corporations can in theory do useful work, but add that in practice they have several drawbacks. We start with the quality of people making decisions in the non-profits. Industry knows that Air Force and, in general, civil service have great difficulty in retaining highly-skilled technical people, for two reasons: money and the job atmosphere. Both these factors work for the non-profits with their studied "university-like" environments. However, to make technical decisions in rapidly-changing technologies you must keep abreast of the latest and best, in industry, and stay there. "Is this possible in a non-profit organization?" asks an advanced researcher in industry. This same researcher offered this opinion on the quality of the individuals staffing the larger non-profits: "They have gotten a few good people but by and large the people who are stuck in order of advancement where they are, are most likely to accept positions.

"From this it follows that a company in industry may get a contract only to find that the project director is less capable technically than their own."

Industry says it is efficient because that is the only way to make money. Take away that money-making drive and down goes the efficiency, and you substitute a relaxed atmosphere. Adding to the relaxed atmosphere is the fact that there is a "kind of lack of a center of responsibility—'they' can put in certain technical inputs into contracts a company in industry gets, which that company may not like. If the system does not work properly, who will get the blame?

"MIT is studying the Apollo guidance system, this is O.K., but what happens later when someone has to build one and is responsible for the end-product? Someone has to be responsible. Better give the contract to a group already proven in the guidance industry, and then subcontract R&D to a non-profit organization. In this way control rests with industry."

Questions Asked — In probing the industry viewpoint, AEROSPACE MANAGEMENT asked, "Is there a better substitute for the non-profit organization between industry and the Air Force?" As in the whole subject of non-profits, there was a great deal of reluctance to talk—even on a not-for-attribution basis. "We have to get along

Allen F. Donovan
Sr. Vice President, Aerospace Corp.

with these people" was the commonest non-commital answer.

And, "Could the U. S. have done as well in missiles without non-profit organizations?" This drew the response from a knowledgeable source that, "We could have done just as well, if not quicker and cheaper historically on the Thor, Atlas, Titan and Minuteman. The people who worked on these projects in non-profit organizations existed somewhere, and were generally in places where they could be used usefully. They did some good work admittedly, but they also got on the wrong foot technically as well, at times."

Delicate Relationship—The relationship between industry and corporations like Aerospace is bound to be delicate and initially at least, one producing industry resentment. It is not always easy to pass over your proprietary secrets to a third party despite the assurances of confidence. "It is a ticklish situation for industry to have to cooperate and lay out to them what we know. One of the facts of life is that if you don't cooperate, the pickings will be slim contract-wise."

ICBM Management—Why did Air Force create non-profit organizations in the first place? In 1953 Air Force organized the Strategic Missiles Evaluation Committee (SMEC) headed by the late Dr. John Von Neumann. This group in February 1954 recommended large-scale effort to develop an ICBM. The committee was convinced that the conventional management organization of prime and subcontractor would not be suitable for the crash program envisioned. In this way, missile pioneer Convair lost the prime contractor responsibility for Atlas, the first ICBM.

Drs. Simon Ramo and Dean Wooldridge, initially members of the Von Neumann committee, headed an organization (a break away from Hughes Aircraft) which provided "technical-staff assistance" to the SMEC. Continuing ICBM and other technical studies were made by Ramo-Wooldridge Corp. in 1954-1955 under Air Force contracts.

From this early relationship with the Air Force a unique procurement arrangement was established, with Ramo-Wooldridge occupying a line position between Air Force and industry contractors, giving "systems engineering and technical direction" to the program. A function normally assigned to the prime contractor, became the responsibility of STL, a division of Ramo-Wooldridge Corp., banned from producing hardware.

By 1958 pressure from industry and Congress forced the separation of STL from what was now Thompson-Ramo-Wooldridge (TRW) into a separate corporation with financial ownership of the division resting with TRW. Air Force was convinced that "STL's technical resources must remain unimpaired and continuously available to the Air Force which lacked such resources within its own house and could not easily find them elsewhere," according to contemporary congressional testimony. The relationship between STL and its owners continued to be a vexing problem to the Air Force due to what a later congressional report called a "growing interest in hardware production."

Millikan Committee Formed—In September 1959 a house subcommittee proposed that STL should become a non-profit institution. STL management would not bite. The Air Force held that dismissing STL would jeopardize the ballistic missile programs. The Millikan committee was formed to find a solution to the missile management problem. How well this committee functioned is still open to certain debate since its final report was presented to the Secretary of the Air Force in January, 1960. In a report to the Committee on Government Operations, (under the chairmanship of Rep. Holifield) dated May 1961, bearing the title "Air Force Ballistic Missile Management (Formation of Aerospace Corp.)" this was said of the Millikan report:

"The brevity of the Millikan report is not matched by clarity. There is an irritating vagueness about a number of points which should have been carefully organized. The lack of precise analysis may reflect an inability of the group to agree on certain important matters, or an understandable disinclination to be too sharply critical of a management organization which several of the members had a hand in sponsoring some six or seven years before, as members of other advisory committees.

"The Millikan committee had good things to say about the Air Force management organization and the Ramo-Wooldridge/STL role in the Air Force ballistic missile programs. But this management organization, the committee suggested, was born of an emergency and adapted to the urgent needs of the time. Now the emphasis should be centered 'on the establishment of continuing management institutions rather than on an expedient tailored to a pressing problem.'

"Merely to continue using STL as before was not the answer, said the Millikan committee. The STL organization, with Air Force bless-

ing, had grown too quickly and had grown too large. The Air Force was thrusting upon it too many tasks 'outside its primary area.' Industry was concerned lest STL became an 'arsenal' for development and production of advanced Air Force weaponry and space systems. Concentrating all this work in one organization without a clear concept of its ultimate size and purpose tended to monopolize technical ideas and dry up other sources."

Aerospace Corp. was formed as a non-profit organization under general Air Force program management for: advanced systems analysis and planning, research, experimentation, initial systems engineering, initial technical direction and general technical supervision in the complete fields of Air Force ballistic missile and space systems.

Aerospace Responsibilities—Under technical program operations, Aerospace starting with a nucleus of 300 engineering and scientific people from STL, is responsible for general systems engineering and technical steering of associate contractors on the following programs:

SAMOS E-6	observation satellite Atlas booster Agena B second stage
DYNASOAR booster	modified Titan II
ADVENT booster	modified Atlas D booster with Agena B second stage, eventually Centaur second stage
MERCURY booster	modified Atlas D
BAMBI	orbital interceptor
SAINT	satellite inspection
TRANSIT	navigation satellite Thor booster Able-Star second stage
VELA HOTEL	nuclear detection satellite

Aerospace also has a technical supervisory role of six additional programs under Air Force Aerospace Systems with other contractors, STL and Lockheed, being responsible for overall systems engineering and technical direction. These are: Atlas, Titan, Minuteman missiles, and parts of Samos (E-1, E-2, and E-5); Discoverer; and Midas programs.

STL was left with primarily systems engineering and technical direction for the Atlas, Titan, and Minuteman missiles in far greater detail than Aerospace's contracts call for. Thus there are now two organizations between the Air Force and industry. STL's responsibilities are transitional but will remain until the Air Force is confident that it can discharge their functions in the three major missile programs.

Functions Overlap—The overlapping management functions between STL and Aerospace create complex problems. These problems are said to be even greater when a program is common to more than one service as with Advent which is a former Air Force ARPA project transferred by DOD to Army. In 1960, STL once again became a competitive profit making arm of Thompson Ramo-Wooldridge Corp.

There have been pressures exerted by Congress to investigate the role played by the non-profits built up in part by such statements by the Comptroller General as: " . . . we believe that it would be advisable for the Air Force to develop in-house capability to provide systems engineering and technical direction for its ballistic missile program." Despite this desire on the part of some segments of government to give these responsibilities to the Air Force, the Air Force does not want them.

The government, in view of the prolifertion and complexity of missile and space systems, is unlikely to allow industry to take management control of weapon and space systems.

The apparently selfless nonprofit organization such as Aerospace seems likely then, to hold on to and carry out the management task for some time to come. The end of their role will come when the Air Force decides against them and not before.

Air Force Position—Perhaps the best summary of the Air Force position comes from Secretary of the Air Force Eugene M. Zuckert, who in a recent speech exhorting industry to manage better than ever before stated, "Important adjuncts in this regard are the nonprofit organizations that we have called upon to help us bridge the gap between industry and the Air Force. These organizations are in a position to make unique and valuable contributions. It is because they are special that we turned to them in the first place. And so they must be kept, if their exceptional potential is to be fully realized. We must be particularly careful that they do not become convenient catch-alls for work which should be performed either by the Air Force or by private industry . . . Above all we must at least make it clear why, in certain instances we need these companies, for certain chosen tasks. Our purpose will be to preserve the usefulness of these non-profit organizations by insuring their scrupulous attention to the proprieties of public service and the bona fide interests of the people of the United States. We must be alert to the hazards of their special status."—What is there in the above statement to indicate lack of support?

Aerospace Corp. Views

Allen F. Donovan, Senior Vice President Technical for Aerospace Corp. gave AEROSPACE MANAGEMENT in an interview a frank rundown on his views of industry criticisms, and the future role of his company relative to the Air Force and industry.

"The question is basically: how do we in a capitalistic system provide the government with certain types of technical skills? What does government want? Creative people work best in certain environments, typically a university. The better-scientists and engineers prefer to work where they can present constructive criticisms, where their function in society can be understood.

"Aerospace Corp. provides the right atmosphere for creative scientific and engineering people wanting to advance technically with the rapidly-changing technologies. The bulk of these people will not work in the military or the civil service. The purpose of the military has been to preserve the status quo. This is basically contrary to the scientific spirit. Technical objectivity is very difficult to achieve anywhere, and

you do not have to make a profit to have it. Naturally, the non-profit organization to be effective must have the highest level of technical competence possible. For this reason, at Aerospace we have striven to attract high-level people from both an educational and experience viewpoint. Demonstrating competence in education, more than 20 per cent of our technical employees have Ph.D.'s, over 50 per cent went beyond bachelor's degrees.

"Average experience level is 12 years in their field. We wanted the type of person who likes to work across systems and across disciplines. A hard core of 300 top people came from STL. Our greatest recruiting problem came in attracting the more than $20,000-a-year program-managers who had demonstrated administrative talents. Naturally, industry was aware of their abilities and had the ability to pay them more than straight salaries with inducements such as stock options and so on.

"In keeping up with the field in technical competence, our people visit contractors across the board. We do not run more than limited experiments in our own labs but we keep aware of what is going on. Even if we do not push the buttons in industry, we observe. There is a free interchange of information. We are as close to experimental problems in most cases as the management of the companies visited. We are slightly farther removed physically but our background is broad. These reviews and observations are valid to keep up with technology.

"The object of our labs is to keep a limited amount of state-of-the-art research so that our scientists can talk to scientists in the field. We can participate in all phases of development without pushing the buttons and still resolve problems between contractors. Only time will tell if you can keep your hand in, without actually doing the work. The idea, after all, is still relatively new, begin proposed by the Von Neumann committee. The best individual companies contribute their best, and this covers airframe structures, propulsion, guidance, re-entry vehicles and many other related sciences. Who will resolve conflicts in the integration of these systems from a group of highly skilled organizations?

"In a new system the first thing to do is to get hold of an industrial concern with knowledge. Because we are a non-profit organization we will often be told their opinions which they would not tell other profit making firms. And, where else would you meet such a group of wide talents in one company as in our own? Our responsibilities are clearly defined and there is no chance of a "relaxed atmosphere" we are held tighly to schedules by the Air Force, and come under constant close scrutiny.

"Congress long ago separated control of the airline industry from airframe manufacturers, in the public interest. The Navy has traditionally used outside architects to design Navy vessels. These architects are outside profit making consultant designers. Yet in the Navy concept the architects have been used for hundreds of years with the understanding that they would not make a profit from the equipment manufacturers. Even with a house you are better off with an architect for planning and supervision. You don't want a profit angle to intrude into this relationship either. Air Force will be better off with architect-relationships for space systems without profit.

"We talk with the contractors on the state of the art and time-schedules. Problems must be constantly realigned to the 'real world' against the 'expected world' which is another reason why there is no 'relaxation' in Aerospace Corp.

"There has been criticism of pay scales in Aerospace, but in reality the six per cent average increase for people joining Aerospace was not more than the average annual increase raise that people lose when they transfer. The problem of high-level recruiting has been in the main solved by the challenge of the job since we cannot offer the advantages of a profit-making industrial concern.

"As for the future, following the review of non-profit organizations asked for by the President and Congress, we will be recognized as fulfilling an intermediate role in technical opinions, unbiased by profit motives. Once this is clearly defined there is a distinct chance that government acceptance of not-for-profit organizations will increase. Although there are many different types, some are very close to industrial companies. So close in fact, that one wonders what is the difference between them and a profit making company like Arthur D. Little.

"Criteria other than profit must be involved in our functioning with an independent position free from influence of profit motive, where the organization can be given proprietory information directly from industry. Who else can obtain such information and use it for the benefit of a program—can the government? Can industry? Our function will become clearer as systems become more complicated. This was first shown in the workings of the Atomic Energy Commission which remains a model of a non-profit relationship between government and industry. Role of the non-profit organization needs definition to make it a logical part of a free-enterprise system. If you over-control the non-profit organization you turn it into a service-like organization.

"For the future, much depends on the international situation and growth of space technology coupled with the Air Force use of space. We were created as an agency to help the Air Force, if the need for us grows we will accordingly grow stronger, if the need declines we will shrink or go out of existence. After all, we can be dissolved much easier than any company with a group of shareholders."

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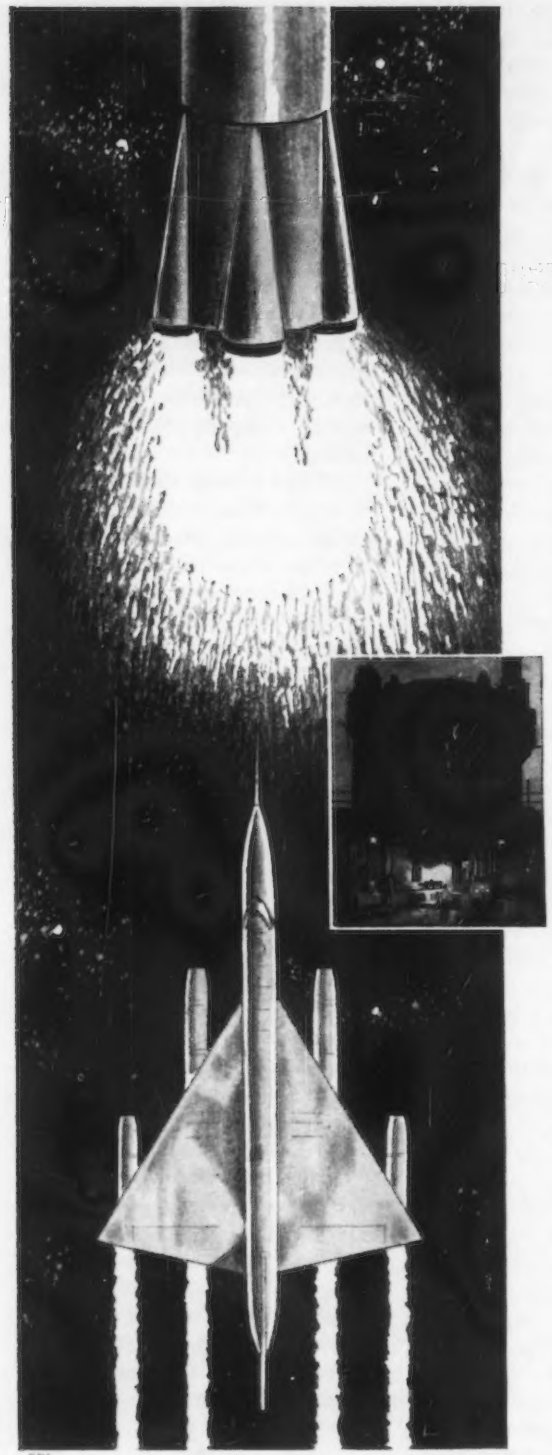

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A LOOK AHEAD

by Donald W. Douglas, Jr.
President, Douglas Aircraft Co.

Much has been said about the technological challenges facing us in aerospace during the next decade: a supersonic transport, improved air-traffic control, better VTOL/STOL vehicles, space flight, etc. That all these and other advances are coming I have no doubt.

But, I suggest, we have not done enough thinking about the non-technical aspects of the future. Among these are economic, political, and philosophical questions that go hand-in-hand with our technological advances. Perhaps the most vital breakthrough we can make in the next few years has been overlooked. We need a realistic understanding of just where the aerospace industry belongs in our national scheme of things. What are the governmental and economic policies and relationships that will be most conducive to effective growth in the varied fields of our industry?

I have no easy answers to offer. I do not think there are any pat solutions. But I do believe we must begin to face up to some tough problems, and abjuring pious platitudes, find good answers.

For example, how should we regard defense industry? Is it truly private enterprise, or is it quasi-public? Is a missile maker in "business" in the same way that a manufacturer of toothpaste is? From one viewpoint there may be great similarity. For example, both have stockholders, both are in business to make a reasonable profit, both require the understanding assistance of the banking community.

Close examination of the missile maker's case develops some peculiar problems, however. This is perhaps epitomized by the recent furor over defense contractor advertising. I would be the last to argue that bombers and missiles ought to be advertised like toothpaste. Yet, I am aware that advertising plays an important role in a private company's ability to command risk capital under our free-enterprise system.

Or take the question of profit margins. In advancing not only its business aspirations, but the national interest as well, defense industry supports a vast research and development effort, including costly facilities. It operates under various policies relating to allowable costs, depreciation, subcontracting, follow-on contracts, and the amount of profit that can survive renegotiation —are they working effectively in the national interest?

The advent of missiles and space systems and the general change in the nature of final products has revolutionized the nature of the aerospace industry. It has also increased competition through the participation of many new companies, some of them well-established titans of other industries. At the same time the cost of remaining competitive — technologically, administratively, and in facilities— grows by such leaps and bounds that bigness is almost a prerequisite to success. How are the letter and spirit of our anti-trust laws to be applied in this situation? Very large companies or groups of companies, and a narrowing of competition, may be an unavoidable part of maintaining a strong aerospace industry. Our British cousins seem to think it is, and have acted accordingly. Have we given this problem enough thought?

Perhaps we need for our air commerce the sort of supporting legislation provided the maritime industry as long ago as 1936. We are nibbling at the problem, particularly with reference to development of the supersonic transport. Of course we do have airline subsidies in effect; but I suggest a massive across-the-board reappraisal may be in order.

I have touched but lightly on some of the problems that, it seems to me, are bound to come into sharper focus during the next few years, and for which I think we must find solutions during the next decade.

As our scientists and engineers move with imagination and courage to new technological achievements, we must not lag in developing the proper foundation of social and economic policies. Determining our objectives, and evolving a philosophy and policies that serve rather than imprison us, is in my view one of the prime challenges of the next decade.

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1963 Defense Budget . . . Prototype For The Future

- *New management techniques will stop wastes in weapons programming.*
- *Budget planning will be a three-step, year-round operation.*
- *"Program Packages" will be combinations of weapon systems from each service.*

by John P. Kushnerick

A revolution is taking place in defense budgeting. And its impact will be felt heavily in the next decade.

The old system which pitted service against service and weapon against weapon for financial survival is dying. A new system is growing in its place. The system integrates long-range strategic planning with financial management.

The fiscal '63 budget, now in the making, is the first to be so drafted. And it is the prototype of budgets to follow. It carries with it a five year projection of strategy and weapon packages all completely costed out. A decision to commence development of a weapon, or part of any program, will immediately imply that funds will be available to carry the job to completion.

Need for Better Management—In outlining why new management techniques are being applied to drafting the defense budget, Asst. Secretary of Defense Charles H. Hitch stated, "wastes have resulted from the fact that our plans and programs for future years have so often over-reached our resources and budget availabilities, with the consequent necessity of killing, curtailing or stretching out uneconomically programs on which vast amounts had already been spent."

General Maxwell Taylor, the President's chief military adviser, has said of the old budgeting system: "In spite of the fact that modern war is no longer fought in terms of a separate Army, Navy, and Air Force . . . we still budget vertically in these service terms." He suggested instead that wars are fought in "task forces, combinations of Army, Navy, and Air Force . . . but since we do not keep our budget in these terms, it is not an exaggeration to say that we do not know what kind and how much defense we are buying with any specific budget."

The budget planning of the future seems geared to the Taylor statement. Money is indeed being provided for specific packages rather than individual services. In the new scheme, Polaris which robbed money from many other Navy projects will now be competing with IRBM's of the other services for money.

Impact on Industry—Now what does this new plan mean to industry? It means more stability. Once a program is commenced, there is less likelihood that it will be suddenly chopped with the catastrophic results that accompanied the Navaho cut in 1957 and the B-70 cut in 1960. The chance for this kind of cancellation will never be completely eliminated, however.

The new budget process will also allow industry to gear more precisely for the future. A tentative five-year budget accompanied by a firm one year budget is a sounder foundation certainly than a vague one year plan that is constantly being revised and re-revised. How much of the five year plan industry will have access to is still a question.

Three Phase Program — The long life cycle, from R&D through useful life, of major weapon systems has made it imperative for these new management techniques so that decision makers can grasp the full cost implications of any major change in planning.

What DOD visualizes under the new approach to budgeting will be a three-phase operation:

- The Review of Requirements.
- The Formulation and Review of Programs, extending several years into the future.
- The Development of Annual Budget estimates.

First Phase—The review of re-

Asst. SecDef Hitch
. . . resources over-reached too often . . .

Presidential adviser Taylor
. . . we do not know what we are buying . . .

quirements has been under way in the DOD since March. Sec. Def. McNamara assigned to the Joint Chief of Staff, the military departments, and the various elements of the Office of the Secretary of Defense, specific projects dealing with the most critical or difficult requirement problems. One, for example, attempted to estimate how many strategic bombers and missiles we will need during the next decade to destroy priority target system. Another estimates, for various major items of ground equipment, the comparative advantages and costs of: (a) refurbishing existing equipment, (b) replacing it with new equipment off the assembly lines, and (c) expediting the development of still better equipment.

These are not requirements studies in the traditional military sense. They are military-economic studies which compare alternative ways of accomplishing objectives laid down in the national security policy document and try to determine the one which accomplishes the most for a given cost or achieves a given objective at least cost. Some of these requirements studies involve complex analyses. They are being conducted by various elements of the Defense establishment with the help of such research groups as the Weapons Systems Evaluation Group, RAND, etc.

Requirements studies are selective rather than comprehensive in scope. They are directed at the most important areas. They will provide a firmer basis for the program decisions in the second phase of the operation.

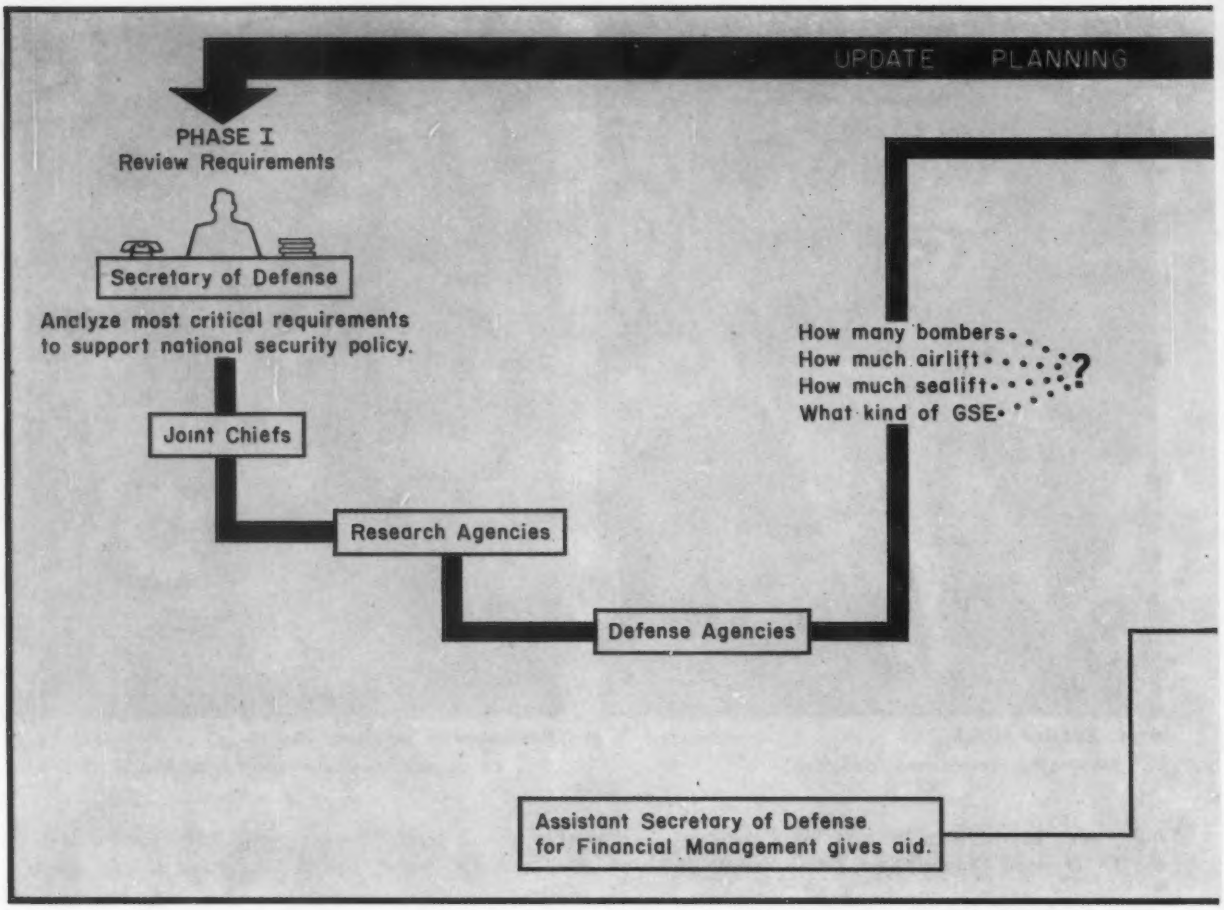
Second Phase—The formulation and review of programs was started in May. No dollar ceilings were assigned to the military departments. They were instructed, instead, to use as a base the projections prepared by the Joint Staff of the Joint Chiefs of Staff. Services were also asked to submit proposals for new programs which, in their judgment, are required to support the basic national security policy. Wherever possible this is projected through 1970. The departments were particularly encouraged to submit alternative forces and programs so that the Secretary of Defense would have before him the principal choices available to achieve the national security objectives. The total costs of each proposed program must be shown for at least the next five years.

The time schedule for the submission of the programs is shown in Table I.

Program Packages—The make up of a typical "program package" and its "program elements" is shown in Table II.

A "program element" is a combination of men, equipment, and installations, whose effectiveness can be related to our national security policy objectives.

A "program package" is an inter-related group of program elements that must be considered together because they support each other or are close substitutes for each other. The Central War Offensive Forces Table II is an example of such a package. In all,



DEFENSE BUDGET . . . CONT'D

there are seven packages. The unifying principle of each package is a common mission or set of purposes for the elements involved.

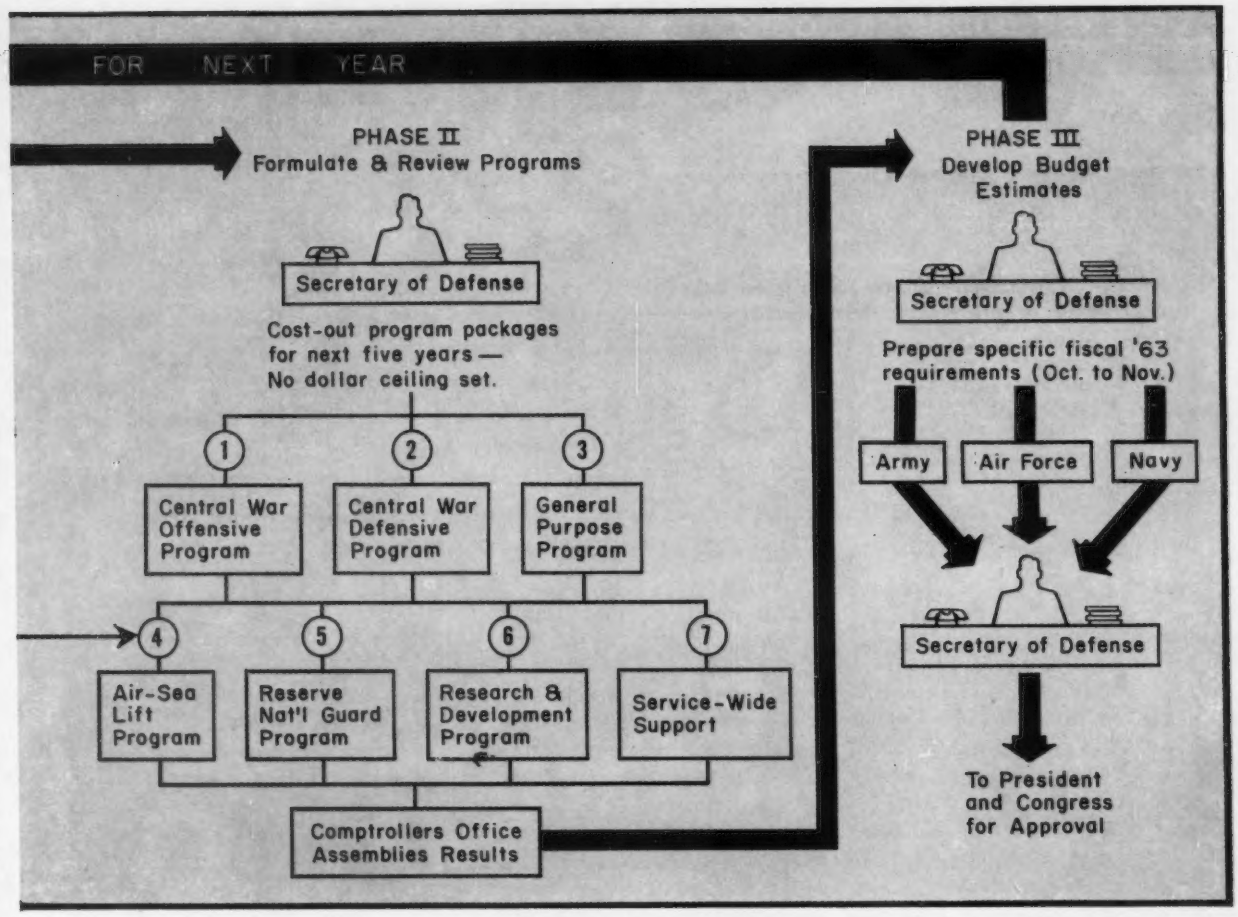
War Offense Package — Program elements included in the Central War Offensive Forces program package, are divided into number of general categories: aircraft forces; land-based missile forces; sea-based missile forces; command, control, and communication system; and headquarters and command support.

Within the aircraft forces are the B-52's (with Hound Dog and Quail air-to-surface missiles listed separately), the B-58's and B-47's (including the reconnaissance version of the B-47), the tankers, and the B-70. Within the missile forces are Atlas, Titan, Minuteman, and Polaris—plus the Thor and Jupiter IRBM's, and the submarine-launched Regulus missiles. Also included in the Central War Offensive Forces package are the communications links and the command and control systems required for the effective direction of the strategic forces, together with the headquarters and command support associated with these forces.

Each service has representation in this package. So, if it is decided that "X" billion dollars are needed to support this program, each weapon gets its proportionate allocation. Inter-service appropriation fights will be resolved here, if the system works as planned.

General Purpose Package—The largest program package is that for the General Purpose Forces. These forces will fight the local or limited wars. This package is organized broadly along Service lines; within Services the basic, identifiable combat units form the program elements. Under the Army are almost all its regular combat units and command support elements. They range from the four basic kinds of divisions through the missile groups and commands to tank units, artillery battalions, air defense units for the Army in the field, and aviation companies.

The Navy's list is even longer. It embraces all of the combatant ships and support vessels, except for the strategic-missile firing submarines, the radar warning picket ships, and Military Sea Transportation Service



(MSTS) ships. All of the Fleets' various aircraft units are also included, except those assigned to the airborne early warning squadrons.

All Marine Corps units are listed under General Purpose Forces, including the Marine Air Wings.

Air Force's General Purpose Forces include principally those units assigned to the Tactical Air Command.

The remaining five program packages are:

- Central War Defensive Forces
- Sealift and Airlift
- Reserve and National Guard Forces
- Research and Development Projects
- Service-Wide Support

Year-Round Effort — The first and second phases of the new budget management will be year-round efforts. Once the initial formulations of requirements and programs have been completed, reviewed, and tentatively approved by the Secretary of Defense, the continuing effort will be concentrated on program revisions to take account of changing conditions, new developments, and new requirements. The Department of Defense will have at all times a tentatively approved program, fully costed, and projected at least five years into the future, to serve as a planning guide to the entire Defense establishment.

In the fall of each year this budget planning and management plan should make it possible to draw up rather quickly a detailed Defense budget. The usual hectic and hurried program review crammed into a few weeks in the midst of the annual budget review will be eliminated. The basic program review will have been accomplished and only a final check and some last minute adjustments should be needed.

Costing-Out Procedure — To speed the translation of approved programs into budgets the Comptrollers Office has asked the Services to submit the costs of each program element by fiscal years and in several ways: (1) By obligational authority and expenditures. (2) By appropriation account and budget title, in line with the present budget structure. (3) By three broad categories of costs — research and development, investment, and operating—covering the three principal phases in the life cycle of a weapon system.

Research and development costs are all costs associated with developing a new capability to the point where it is ready for introduction

TABLE I

Program Package Submission Schedule

Program Packages	Submission Date To OASD (Comptroller)
I. Central War Offensive Forces	July 3
II. Central War Defensive Forces	Aug. 21
III. General Purpose Forces	July 31
IV. Sea and Airlift Forces	July 19
V. Reserve and National Guard Forces	July 10
VI. R & D (Including "Space")	Aug. 14
VII. Service-Wide Support	Aug. 28
VIII. MAP	Aug. 31
IX. Classified Projects	Aug. 31
X. DOD	Aug. 31

TABLE II

PROPOSED PROGRAM PACKAGE & PROGRAM ELEMENT LIST

Central War Offensive Forces

Aircraft Forces
- B-52 (Including GAM'S)—Air Force
- B-58—Air Force
- B-47 and RB-47—Air Force
- KC-135—Air Force
- RC-135—Air Force
- KC-97—Air Force
- B-70—Air Force

Missile Forces, Land-based
- Atlas—Air Force
- Titan—Air Force
- Minuteman H & D—Air Force
- Minuteman Mobile—Air Force
- Thor—Air Force
- Jupiter—Army

Missiles, Sea-based
- FBM submarines—Navy
- Regulus submarines—Navy

Command, Control and Communications Headquarters and Command Support

into operational use. Such costs include not only the equipment (prototypes, test vehicles, etc.) required in a development program, but also the related facilities, supply, and personnel costs, where applicable.

Investment costs are the one-time or initial outlays required beyond the development phase to introduce a new capability into operational use (including initial training, initial stockloads of spares and supplies, etc.).

Operating costs are the recurring costs required to maintain and operate the capability year by year throughout its projected life.

Early "Weed-Out"—Culling out of programs, will be done in the research and development stage, before heavy investments are made in committing the system to production. This is one reason why DOD now separates the R&D from the investment category. Costs involved in a decision to produce and deploy a weapon system as contrasted with the cost of its development can be plainly seen. Operating costs have been a hidden charge in the past. The cost of operating a B-52 wing for five years is roughly equivalent to its investment cost—about $500 million in each case. The ratio of operating to investment costs varies widely from system to system.

The primary function of the Comptroller's office in the new set up will be to assemble and organize data, and to review specifically the cost estimates. The evaluation of military effectiveness will be the primary responsibility of the military departments and the Joint Chiefs of Staff. The Director of Defense Research and Engineering will review and advise on the scientific and technical aspects of all programs. The Assistant Secretary of Defense, Manpower, will advise on the personnel aspects, etc. In this way the full knowledge and skills of all the principal officials of the Department of Defense will have a chance to exert themselves in the planning.

Phase Three—By the end of September the Secretary and Deputy Secretary of Defense were scheduled to have established a tentatively approved over-all Defense program for the next five years. During October and November the Services will prepare, and the office of the Secretary of Defense will review, the annual budget requests and final decisions will be made on those portions of the approved programs which are to be financed in the fiscal year 1963 budget. This will be Phase Three.

Refining Report Process—This revolutionary planning-programming-budgeting process was undertaken on a "crash" basis for fiscal '63. This Fall new reporting systems will be set up for future needs to meet the new process. Three contractors, who have done pioneering work in relating costs to weapon systems and programs will aid DOD. They are RAND, Stanford Research Institute, and the Institute for Defense Analyses.

The objective is to develop an integrated reporting system which will provide reliable cost and program data in terms of the program elements and packages. It is expected most changes will be effected within 2 years.

With this technique, the Secretary of Defense will have an integrated financial management system specifically oriented to the manner in which he has to make decisions—by packages related to military missions. The policy making a power of the budget bureau will be diminished, and the appropriate military, and civilian research specialists will have the major voice in advising Sec. Def. on defense needs.

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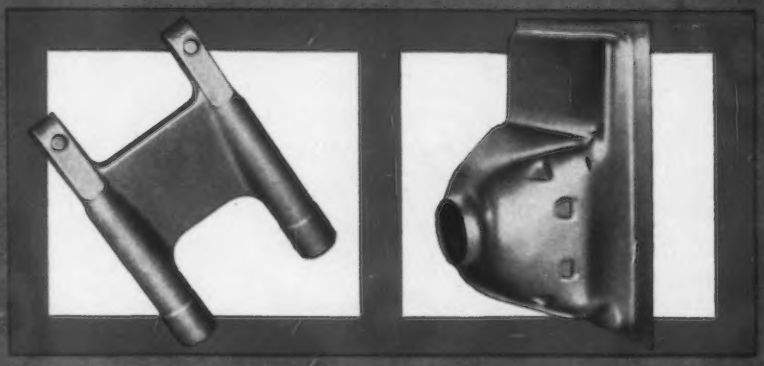

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How to SURVIVE in the Component Market

- *Planned approach to military marketing is needed to avoid financial disaster.*
- *Lower-tier contractors must become customer oriented.*
- *Major shift is occuring from a technology-oriented market to a marketing-oriented technology.*
- *Component makers should spread sales and overhead over a broad base before climbing the contractor tiers.*

Here Are Some Important Tips . . .

by Harry Williams,
Senior Economist, Institute of Defense

Military marketing is now a permanent part of the economic landscape. We who do business in the defense area have a lot to learn about this facet of marketing. There is very little published material that comes to grips with the problem.

My concern is with the component level of the market. These items form the broad base of the military-market pyramid shown in Fig. 1. Equipment includes items from transistors to major pieces of missile guidance systems.

A company in this level of the market does from $25 to $150 million per year in business. Sales are likely to be split between:

1. Sales direct to the military purchaser.
2. Sales to prime contractors of the Federal Government.
3. Sales to major subcontractors who are selling to prime contractors.

Thus, the marketing know-how and effort stretches across a wide spectrum of skill levels and customers. It includes direct prime sales to the Government on a small scale, direct subsystem sales to weapon and support system prime contractors, plus lower level subcontracting to direct subcontractors.

The Problem—The real marketing problem centers on the fact that the approach to and type of sales effort varies at each customer level. A good marketing manager can solve the problem and successfully meet the challenge. He will optimize the use of his limited overhead and thereby achieve profitable business opportunities in his market.

Economist Williams
. . . spread the overhead . . .

Organizing A Department—Marketing in the military area demands an organization thoroughly and diversely informed in all marketing administrations. There must be a Market Research and Planning section of very senior research people. It would most likely be composed of judgment-oriented economists. These men must understand

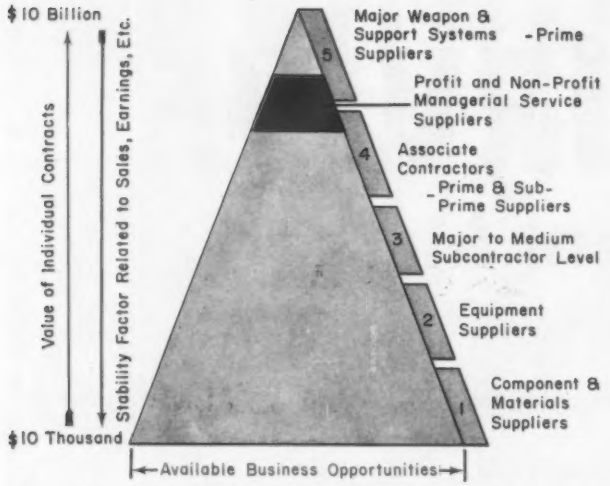

Fig. 1. The total military market can be compared to a pyramid. There are few contract opportunities at the top, but great dollar volume possibilities. Near the bottom, there are many contract possibilities, but each is relatively small in dollar volume.

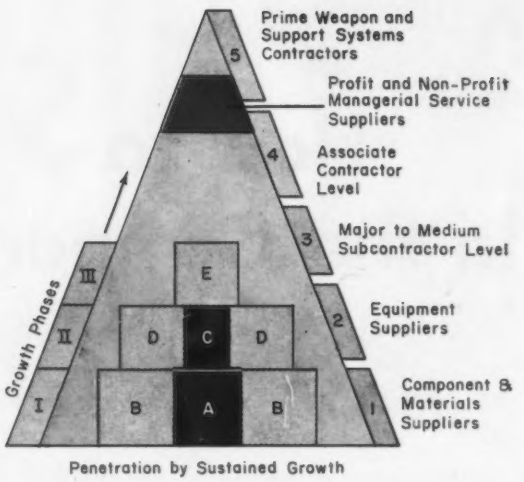

Fig. 2. Vertical penetration from the bottom up, without broadening sales in fields of achieved capability, is risky. Overhead is generated at each new market level and the company fails to spread overhead over a large number of contracts. The structure will collapse.

government budgets, carry out continuous analysis of shifting military and economic strategies, and thereby integrate the company's capabilities with weapon and support systems requirements over the forecast period. From Market Research and Planning, management must receive a highly reliable and timely image of the ever-changing parameters of the segments of the military budget applicable to them.

The basic function in military marketing in the 60's is the Market Research and Planning function. Without a planned approach to the military market, a small to medium sized firm may promote its financial demise. It could bid on contracts in such random fashion that the percentage of contracts won would sink lower and lower while the overhead burden climbs higher and higher.

And effective marketing effort means that a subcontractor must engage in a sophisticated advertising effort. This is difficult because of secret classifications on many products. Advertising must create an impact. It must contribute to an awareness of his capabilities in both government agencies and major prime contractors.

Technology Oriented Marketing—The decade of the Fifties was one of surging and dynamic, order-of-magnitude, improvements in equipment technology. During these years the component and equipment manufacturer who was in the vanguard of the new technology could virtually ignore the marketing of his products. There were years of fiscal plenty with many new products and technologies available, and often they were temporarily unique to particular companies. Both the government and the major prime contractors literally came knocking on the door. It was an age we could characterize as the era of **technology - oriented marketing.** Technical personnel and newly risen managers dominated the component sector of the defense business. Many engineers with little marketing know-how or experience were suddenly cast the role of managers of multi-million dollar technologies that needed only to be produced in order to be sold. Very little awareness of the growth curve of new technologies was shown by the technical managers. They had no time to establish themselves as customer-oriented producers. They were suddenly at the plateau at the top of the demand schedule for their new products. They rode a merry surfboard up the slope of an exponential growth curve. Suddenly they found at the crest of the wave that only a crash marketing effort could keep them from drowning in a sea of competitive bids.

In the first decade of growth in a new industry, a firm can ride the exponential trend of the industry by staying ahead of competitors' technology. There is little knowledge required in terms of the sales environment. If one sale is missed, another is made around the corner. The age of the technological sale permits a company to be little concerned with the customer. No continuous service and follow-through is required.

The Big Switch—The decade we are entering already shows signs of being vastly different. Military equipment and component suppliers will find it necessary to shift from **technology - oriented marketing** to **marketing-oriented technology.** The technical capability is still the basic

Fig. 3. Overhead is minimized by spreading it over a greater amount of sales at each level of capability. Markets served in order of attempted sustained penetration should be: (A) Basic capability; (B) Most easily penetrated and stable markets; (C) Existing equipment level market; (D) Most easily penetrated equipment market with present capabilities; (E) Associate contractor status, but only after maximizing base at component and equipment level.

necessity. But it is not sufficient to close the sales loop in the Sixties. The marketing effort must turn the company's attention to the customer's needs, whims and requirements. Technology is now a means to an end, that of selling a product in which it is incorporated.

Much more knowledge and appreciation of the sales environment or the end-product environment is necessary. Instead of advanced technologies attracting the customer to the company, it must locate the customer and attract him to its technology. In short, military component suppliers must become customer-oriented just as their commercial counterparts did long ago. The customer must be served with continuous, open-end efforts that contact him at all levels in his organization. He must be offered the hardware and the associated support and services that go with it. The customer's problems and needs must guide the firm's research that go with it. The customer's problems and needs must guide the firm's research and development efforts in the coming decade—much more so than in the past decade.

Now, what can the marketing function provide to a component and equipment supplier that will enable him to survive the rigors of becoming customer-oriented and achieving healthy growth during the decade ahead.

Nature of the Market — The nature of the total military market may be compared to a pyramid of contractual opportunities (See Fig. 1). These range from the very few major weapon systems at the top of the pyramid to the multiplicity of business opportunities at the component and material level at the bottom. The value of individual contracts correlates directly as you ascend the pyramid. Stability in terms of sales and employment levels for the individual company increase as you approach the broader areas at the bottom of the pyramid. There are more business opportunities in the component and equipment levels. Established firms can therefore continue to bid and win sufficient business for stability of operations. It is from this solid base that the equipment and component supplier must work. The growth of such a company may occur in either the horizontal and/or vertical realm of the pyramid.

The focus of the marketing departments of military component and equipment suppliers can take two approaches in improving a company's position in this market during the next decade.

Two Approaches—The first approach is to try to climb the market levels of the pyramid in a narrow vertical fashion (See Fig. 2). This means the component and equipment supplier attempts a vertical takeoff to the major subcontractor, and associate contractor levels of the military market spectrum. This can be both very risky and tremendously expensive. Loss of one contract can tumble you back down the scales or loss of a few at the bottom can cut the ground from under your vertical integration effort. This is the most expensive and hazardous approach to climb up the levels of the pyramid of market opportunities.

The most effective marketing drive for the bottom tier manufacturer is a step-by-step route up the pyramid (See Fig. 3). He should comb the market for more opportunities in his established level of capability. As these are gradually exhausted he should raise his level of capability up and then spread horizontally once again across the business opportunities at that level. In this manner, he is minimizing and reducing his overhead as he goes. Overhead must be renewed at each level he climbs higher. He is deploying in an assured evolutionary manner from an increasingly stable base. This is vertical integration from the bottom up and is the meaningful approach for the component and equipment supplier in surviving as well as achieving stable long-term growth during the next decade.

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Role of Solids in the 60's

● *Stepped up pace forecast for solid rocketry*

by Dr. E. R. Roberts, Assistant Manager
Solid Rocket Plant, Aerojet-General

Two widely separated paths lie ahead for solid rocketry in meeting the challenge of increased payloads, reduced costs and increased range.

- The first leads toward the development of more efficient power plants through progress in the state of the art.
- The second path leads to use of current techniques for very large segmented rockets for space vehicles.

Though the trends are different, both will proceed at an increasing pace during the coming few years.

Projected Progress—In order to realistically project our thinking along the first path, we have to assess the anticipated progress in both inert materials and in the propellant formulations we expect to employ.

To be extremely conservative, we believe that in 1964 glass filament chambers with ultimate composite strength of 135,000 psi, corresponding to a strength-to-density ratio of 1.8×10^6, or that titanium with an ultimate strength of 200 to 210 psi corresponding to a strength-to-density ratio of 1.15 to 1.21×10^6, will be available.

On the basis of available information, it is clear that during the next few years nozzle weight will be reduced by 25 percent compared to the lightest gimballing nozzle successfully tested to date.

In order to utilize the aft closure to best advantage, and also have minimum losses from poor flow conditions, a single nozzle is inevitable. To provide thrust vector control, this nozzle might incorporate fluid injection, or, be gimballed with jet tabs to assure the required roll control. The latter concept has been tested for operational ICBM's by Aerojet.

Improvement in propellant formulations in the future will arise from using more energetic oxidizers which will enable us to formulate propellants up to 300 sec theoretical specific impulse. Integrating these advances in propellant with advances in more efficient inert component parts, it appears that in 1965 we can develop units with a mass fraction of 97 per cent and with propellants having specific impulse of 265 sec capable of obtaining a theoretical burnt velocity of 25,600 ft/sec. This would represent a 44.5 percent improvement even compared to the most advanced version of units presently in development. It is significant to note that this improvement is possible simply by exploiting the natural growth potential of already-used materials and manufacturing techniques; it does not require any technological breakthrough.

This in brief is the anticipated progress in the development of more efficient solid rockets during the next few years.

Space Economy—At the same time there is another facet to the future of solid rocketry — that of large propulsion systems for space vehicles. And these systems will follow a different trend. They can and are being developed now within the present state of the art. Regardless of whether we think in terms of putting a satellite in orbit around Earth or exploring the nearby planets, rocket motors of substantially larger size than those presently built are

TABLE I

SOLID PROPELLANT COST AND CHARACTERISTICS

PROPELLANT TYPE	STANDARD THEORETICAL Isp	PROPELLANT COST, $/LB
PU	264	.60
NPU	265	1.50
HP	278	3.00
NO_2 ClO_4	281	3.00
NF_2 ClO_4	292	4.00
N_2 H_4	298	5.00
NF_2	298	10.00

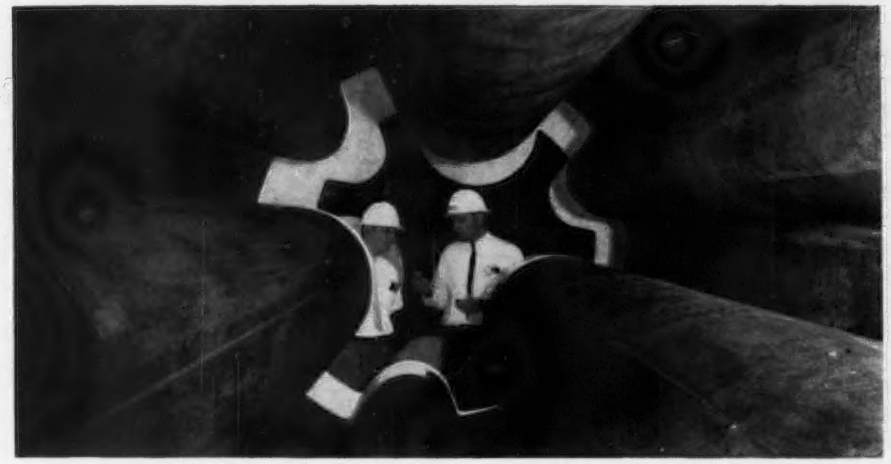
Aerojets' Roberts

. . . $1.50 per lb. in 30 months . . .

along two separate paths:

- *(1) Advancing the state-of-the-art in cases, nozzles and propellants.*
- *(2) Using present technology to build big, segmented, space boosters.*

- *Goal is more range, more payload, and less cost.*



Giant 100-in. diam solid rocket segment is examined by Aerojet test engineers. Four such segments composed 500,000 lb thrust motor which set total impulse record in August.

required. The paramount factor in deciding whether a liquid or solid propulsion system should be used (if both can do the job) will be economy. In the case of a human payload, reliability will be paramount.

While a precise cost comparison with solid and liquid boosters could be made only when both a solid and liquid booster capable of performing exactly the same task would be developed, produced, and deployed, it is possible to calculate indexes which can serve as guide lines in a preliminary analysis.

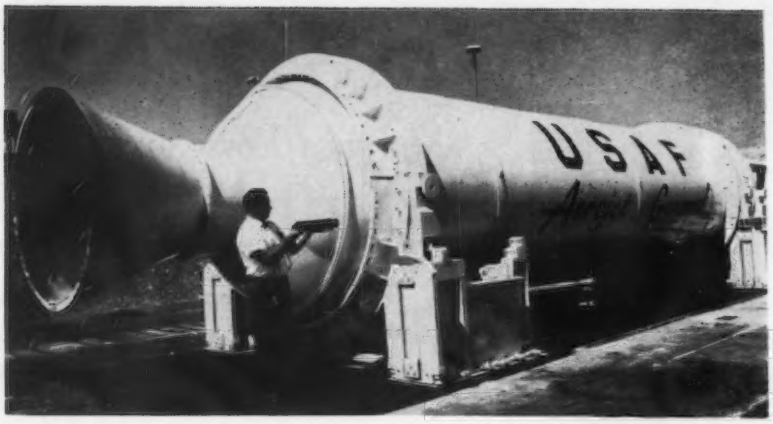
First, let us take a look at what a large rocket will cost in production. Assuming that the rocket will have a 90 percent mass fraction, each pound of rocket will have 0.9 lb propellant and 0.1 lb hardware. With continuous mix, polyurethane propellant can be processed in quantities of 500,000 lbs or more for $1.00 a lb, including the raw material costs. The inerts of an unsophisticated large rocket production is expected to cost between $6 to $10 a pound. This results in a cost of $1.50 to $1.90 a pound of rocket.

Solids Are Heavier—Now let us see how much heavier we have to build a solid rocket than a liquid one for the same task. For this purpose, we express from the theoretical burn out velocity equation the ratio of weight of a liquid to a solid booster capable of carrying the same payload. The resulting equation is graphically shown in Fig. 1.

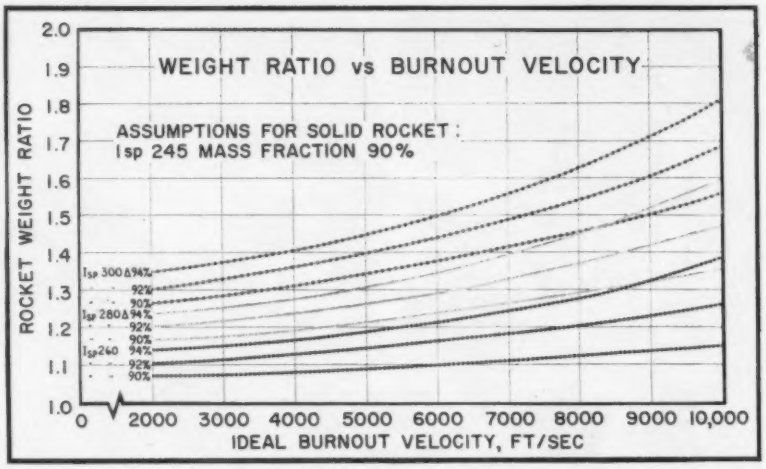
This chart simply shows that to obtain 10,000 ft/sec burn out velocity for example, with a solid booster with 90 per cent mass fraction and 245 sec specific impulse, the solid must be 1.4 times heavier than liquid booster having 94 per cent mass fraction and 260 sec specific impulse.

This calculation does not include the difference in actual drag losses and negative acceleration losses, the latter of which would favor the solid rocket. From this simple calculation, it appears that neglecting cost differences in handling and logistics and those introduced by different degrees of reliability the cost of a liquid booster per lb of rocket must be less than $2.70 in order to be competitive with the solid rocket on a unit price basis.

To get the complete picture, the pro-rated development cost, deployment cost, and the potential recov-



Twenty years of fantastic growth in solid-propellant rockets are depicted in the 28-lb thrust held by an Aerojet technician and the half-million lb thrust engine the company fired recently.



ery and reuse cost must be taken into account. This cursory comparison of economies indicates that the use of large solid rocket boosters should be seriously considered. But lets review its present state and some of its potential applications.

Solids More "Flexible" — Substantial effort is being spent at Aerojet's Solid Rocket Plant to develop an extremely economical large solid propellant rocket motor. These large units employ the "building block" concept which alleviates problems in transport and manufacture, and, because of the possible combination of different numbers of segments, provides a flexibility in the use of the unit.

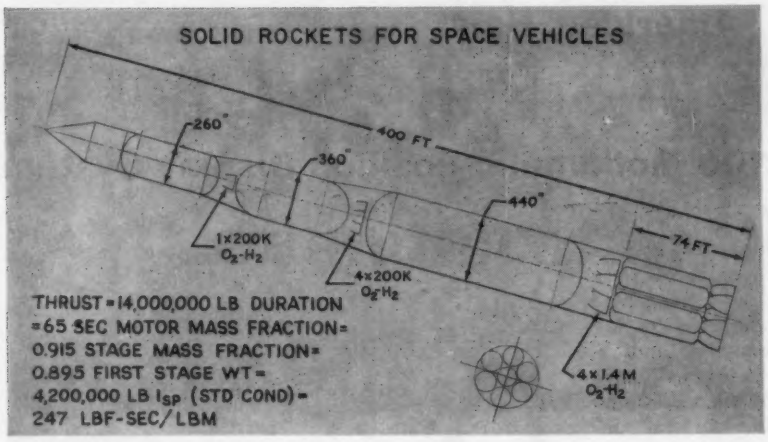
This flexibility is perhaps the key to the development of the long duration, extremely high thrust solid rocket. By developing one basic motor to which segments can be added or subtracted, we will have a motor that can be utilized as a booster unit for a wide variety of applications. We will be in a position to save time and money since we will not be forced to develop a propulsion system for each new vehicle.

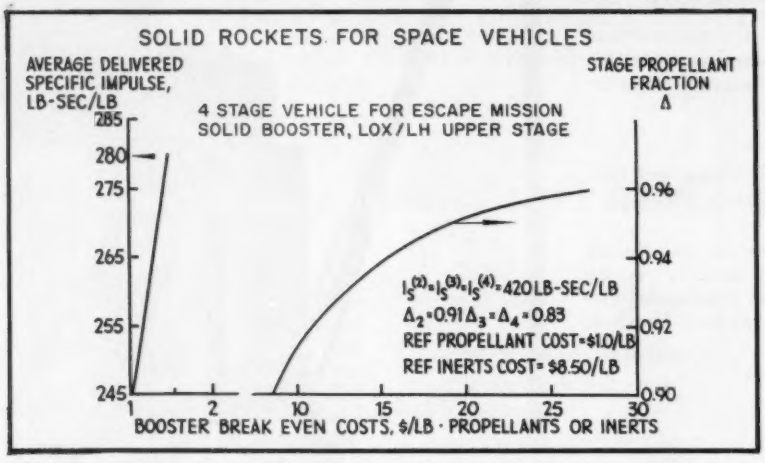
Furthermore, the large segmented solid rocket motor—to use a crude comparison—is just like the railroad diesel which has and still is combating obsolescence because of its economy and reliability. We just add segments or diesel units in order to boost a heavier load.

Successful Tests — The segmented, or "building block" concept was successfully tested first in a 2000 lb scale motor. The unit employed a standard polyurethane propellant in a rolled and welded chamber. In the full-scale units undergoing development, a wide variety of thrust levels and durations can be attained by merely changing the burning rate of the propellant and by adjusting the nozzle throat. In May 1961 a segmented motor, each segment weighing 25 tons, was successfully tested. In June, Aerojet ground tested a 55-ton motor with three segments that produced about 500,000 lb total thrust. In August, the steel case from the center segment and the nozzle exit cone of the June firing were reused in a 4-segment rocket called the "largest solid propellant rocket" ever tested.

Booster for Liquids — Even though the large segmented solid unit was planned as a demonstration of feasibility of large rockets, there are a number of applications where it could be put to good use. For example, a preliminary analysis has been made for using it as a JATO unit to augment the take-off thrust of one large standard liquid propellant space vehicle. In such an application, two of the booster units would increase the take-off weight approximately 200,000 lb; the total take-off thrust would be more than doubled. The use of the boosters results in a 4000 lb increase in payload for the 300 nautical mile mission. The cost per lb of added payload is estimated to be 30 per cent less than the cost of the original payload. This vehicle could also be considered as a possible launcher for the full-scale flight test of the Apollo re-entry capsule. It has the capability to propel 5136 lb payload such that it reenters Earth's atmosphere at 400,000 ft altitude with a reentry velocity of 36,000 ft/sec at the reentry angle of 2 deg.

Using "Flexibility"—Here is an excellent demonstration of the flexibility of the segmented rocket. Take the same unit as used in the previous example, but add to it one mid-


SOLID ROCKETS FOR SPACE VEHICLES
260"
400 FT
360"
440"
74 FT
1×200K O2-H2
4×200K O2-H2
4×1.4M O2-H2
THRUST=14,000,000 LB DURATION =65 SEC MOTOR MASS FRACTION= 0.915 STAGE MASS FRACTION= 0.895 FIRST STAGE WT= 4,200,000 LB Isp (STD COND)= 247 LBF-SEC/LBM



dle segment. Adjust the nozzles so that the unit operates at the same pressure as before. Doing this we obtain a larger thrust unit. Four of these, clustered units, could be used as a first stage with Saturn upper stages to propel 18,000 lb payload to escape velocity. Each of the motors would have a mass fraction of 90 per cent resulting in a mass fraction for the cluster of 88 per cent.

The same mission could be accomplished with a single segmented rocket of 140-in. diameter. There are numerous advantages in using a single segmented motor, from the standpoint of reliability, cost and performance. Also this larger unit could be used as a new building block for applications which demand even larger total impulse, such as the Nova mission, which would require seven of these large 140-in. diam units in clusters, as shown in Fig. 2. These units would deliver 2-million lb thrust for 65 sec each.

Considering the work which is being done in the field of large segmented rockets today, a rather short development schedule is believed feasible. It is estimated that it would take just 30 months from "go-ahead" to complete development.

Development Cycle — In the scope of the development we would test in five static test firings the single segments to establish design soundness before complete units would be tested in three full scale static test firings. Since 160 in. is about the upper limit of diameter which could be accommodated with present transportation systems, it is of interest to see what is the maximum feasible thrust we can obtain from units of this diameter without impairing the 90 per cent mass fraction. There are indications that with present propellants 2.25 million lb thrust is about the maximum we can get in a 160-in. diam unit without detrimentally affecting the mass fraction of the unit.

Advanced Propellants — Now, how about the advantage that could be derived by introducing the more advanced propellants and higher strength structural materials as they become available. Trade-off calculations permit us to draw graphs which show how much more expensive an increased specific impulse propellant or a lighter chamber can afford to be and yet result in a more economical unit for a given mission. As an example, we used the solid booster application for Saturn C-2 vehicle. Fig. 3 represents a break-even cost of the inert components as a function of the mass fraction. The reference value assumed for booster costs are $1.00 per lb for a propellant with a specific impulse of 247 sec and $8.50/lb for inert component parts for mass fraction of 90 per cent. This chart shows that if a propellant formulation yielding 270 sec specific impulse costs more than $1.33, the propulsion costs for the same mission would increase, compared to the one using present polyurethane propellant. Also, on the same chart we can read that a 20 per cent reduction of inert components weight is economical if the corollary cost increase is less than $3.00/lb of hardware.

Using Table I, which shows expected cost of improved propellant formulations, it becomes evident that the presently available and fully developed polyurethane propellant is the most suitable propellant for large solid rockets.

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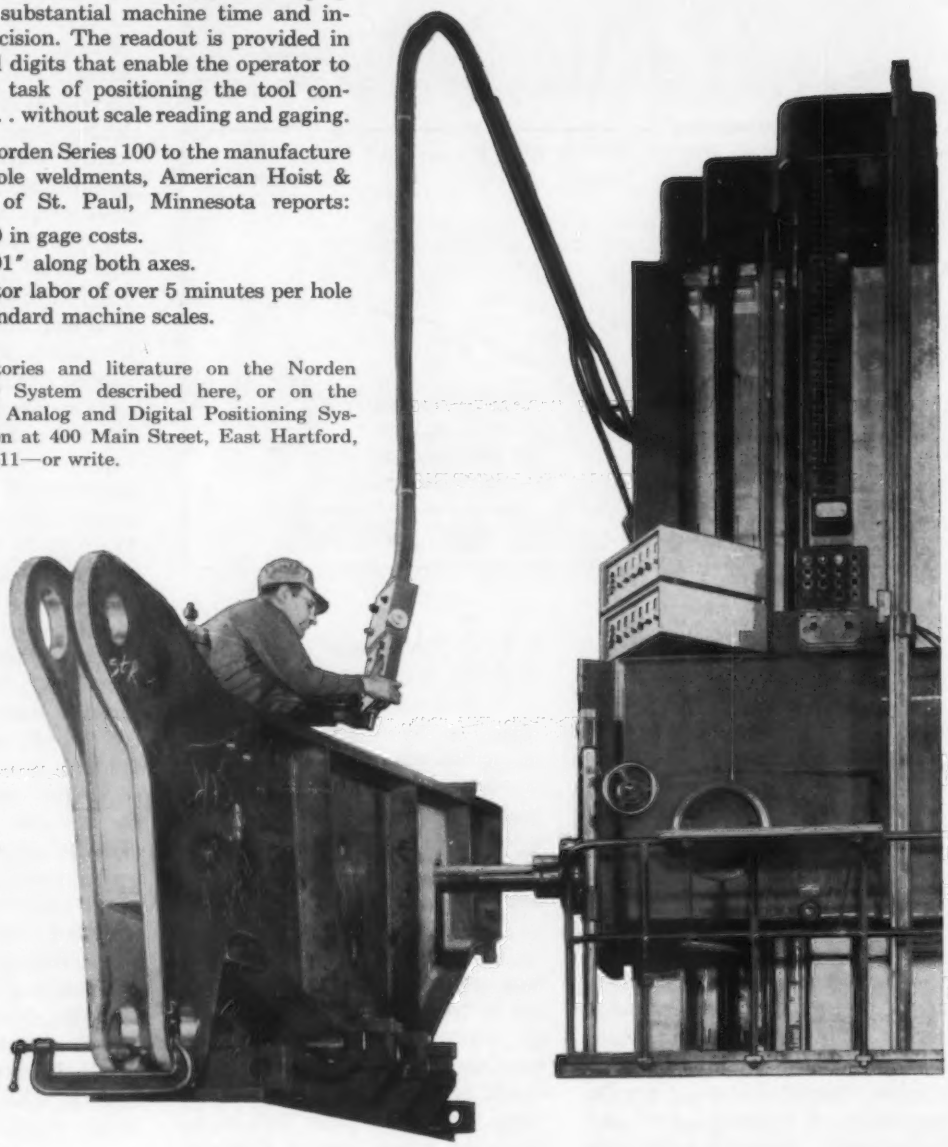
For other case histories and literature on the Norden Modumatic Display System described here, or on the Norden Modumatic Analog and Digital Positioning Systems, contact Norden at 400 Main Street, East Hartford, Conn., JAckson 8-4811—or write.



NORDEN

division of UNITED AIRCRAFT CORPORATION

DATA SYSTEMS DEPARTMENT
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Why We Need Communication Satellites

- *World-wide scope of military and industry management makes "infallible" communications a must.*
- *Long-distance messages up 3000 per cent in past 30 years within U. S.*
- *Similar trends evident in overseas messages.*

. . . cables can't handle the load . . .

by S. Peter Kaprielyan,
Technical Editor

EDITOR'S COMMENTS — The NASA-AT&T contract for communication satellites is raising eyebrows both in and out of Congress. Growing concern is that the American Telephone & Telegraph Co. may end up monopolizing the field.

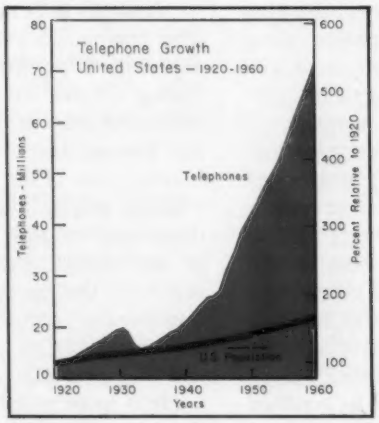
From the receiving end, AT&T is attempting to allay fears by stating that it does not intend to control nor dominate the satellite system. Briefly, AT&T defends its position by the following argument:

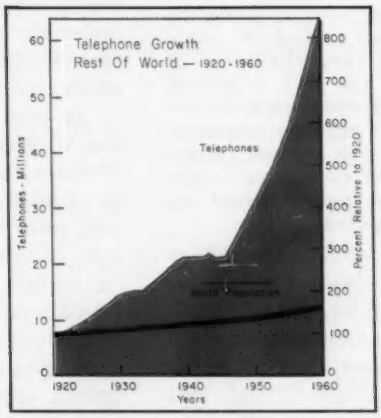
Ownership of the satellite system proposed would follow the traditional pattern. Each company or agency taking part could share the cost of the satellite system. Those not wishing to share in the ownership could lease circuits in the system.

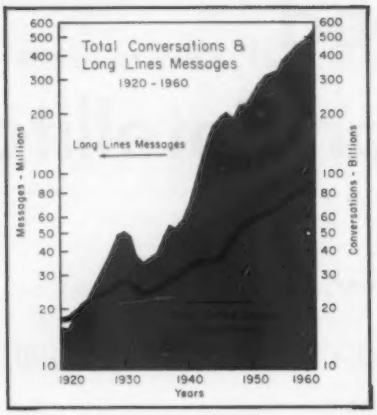
The Bell System now has over 160 working agreements with telephone companies and administrations overseas and, in many cases, these same agreements could be modified to add in a satellite microwave system.

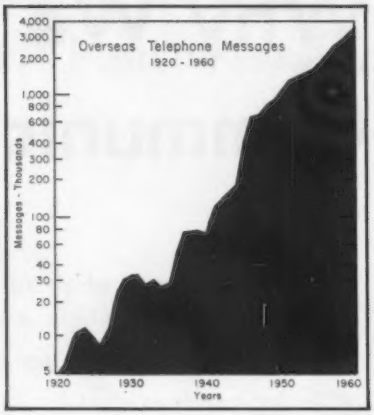
Use of the U. S. portion of the satellite system, including ground stations, could be shared by all present and future U. S. international communications carriers for any services the Federal Communications Commission might authorize them to provide.

Many other companies and industries would share in the business opportunities that the development of a satellite communication system would provide. Most of the money spent for electronic gear and other equipment and services would go to companies









outside the Bell System. Rockets and the launchings for the satellite system would also be supplied by private industry. All would be under competitive bidding.

Creation of this satellite system would not under any circumstances preclude the development of other space communication systems.

NO DECISIVE ACTION—At present decisive action on this program is being withheld until the priority of the following issues becomes established:

- **Importance of a communication satellite system initiated by the U. S. instead of the USSR.**
- **The risk of monopolistic domination by already-powerful companies in the communication business.**
- **The surrender to Government of yet another field of private enterprise.**

While debates continue on the "who" and the "how" of a satellite communications system, no argument is heard about the "why" of it. The need for such a system comes into full view when the recent growth of existing communication systems is studied. Highlights of AT&T studies on future communication needs, based on growth rate, follow.

There are about three billion people on our planet. Only six per cent of this number, some 180 million, live in the United States.

Yet, at present, the U. S. exclusive of Alaska and Hawaii, has 55 per cent of the world's telephones. Hence, a great increase in telephones is due abroad as the other 94 per cent of the world's people become more industrialized. We shall be communicating with many of these people by telephone and by television.

The total capacity of present transoceanic circuits (shortwave radio and cable) is very limited, compared with our domestic communication circuits. All the transoceanic circuits comprise a total bandwidth of about one megacycle. The backbone circuits across the U. S. afford about 100 times as much bandwidth.

In part, circuits within the U. S. are made up of cable pairs and of coaxial cables. A single coaxial cable on land has a fifty times greater bandwidth than a submarine cable. This is because it is possible to put high-performance amplifiers along coaxials often, to supply them with power, and to maintain them.

In part, however, communication is easier over land because microwaves are used. Microwaves travel in straight lines over line-of-sight paths between towers on hilltops; short waves are bent around the horizon somewhat variably by the ionosphere. The use of satellites promises to extend microwave communication across the world. Such systems would not need be confined to telephonic communication. They would carry data as well as voice, and television signals. At present, all our telephone circuits across the ocean together afford only about a quarter the bandwidth required for one television signal. Broadband communications by microwaves could offer transmission of many television signals and thousands of voice signals.

The promise of satellite communication with the majority of mankind opens up a potential demand for microwaves that could not have been foreseen even as recently as in 1957. Experience shows that the demands for communication services have consistently outrun advances in technology. Only through careful planning now can the needs of the future be met adequately.

Growth in Communications— The communications industry has experienced phenomenal growth during the last 40 years. This is especially true in North America and Europe, and to a lesser degree in other parts of the world. Accompanying graphs illustrate the true dimensions of this growth. Much of this growth was attainable because of the availability of new transmission techniques using wire and cable carrier, coaxial cables, and microwaves.

It is to be noted that conversations in the U. S. were five times

as great in 1960 as in 1920. This shows an increase from 17 billion to about 88 billion, or at about the same rate as the increase in phones. But, in this same period long-distance messages increased from 16 million to over 532 million—a growth of over 3000 per cent. Likewise, after the start of service across the Atlantic in 1956, traffic to England increased 90 per cent in one year. The same trend has been evident after establishment of cable to Alaska and Hawaii.

A new channel utilization system is being used to almost double the number of conversations a cable can handle. This is the Time Assignment Speech Interpolation (TASI) system which uses the silent intervals in each half of a two-way conversation. Method amounts to high-speed switching to interleave the voice spurts of different conversations. AT&T believe that no further increase in the capacity of existing submarine cables will be practicable.

Presently, 67 overseas countries or areas are served by direct communication links. In addition 62 others are served by switched links. This brings to 129 the total points with connections to the U. S. mainland. The total circuits today are only a start toward meeting the potential need for world-wide communication.

Initial Plan — AT&T's present plan calls for about 50 active repeater satellites in random polar orbits at 7000 mi. This would be backed by some 26 transmitter-receiver terminals across the world. The number of satellites in system will allow one satellite to be used by one pair of terminals, while another satellite is being used by another pair of terminals. This will make possible direct contact with the major countries of the world without intermediate facilities in other countries. In many cases, this is not possible via submarine cables.

Coordination between adjacent terminals will enable each station to beam toward a different satellite. This will allow re-use of same frequency assignments around the world.

This plan assumes that one frequency band 500 mc wide (composed of four 125 mc assignments) can be used for 600 telephone circuits or one television channel in each direction. Active repeater satellites require four-frequency assignments for two-way point-to-point contact. Each installation will consist of: two 60-ft diam dish, transmitting antennas; two 50 x 50-ft horn reflector receiving antennas; and two beacon-tracking units for directing the antenna systems. Each ground station will also have a standby transmitter and receiver. Emergency power equipment will be provided, as will adequate land and building space. Duplication of antennas, transmitters and receivers will allow a "no-break" switch when transferring from one satellite to another.

Present estimates place the cost of basic facilities for 600 telephone circuits and for television service between each of the 13 pairs of world-wide terminals to about $170 million.

SUGGESTED GROUND TERMINAL LOCATIONS FOR SATELLITE COMMUNICATION SERVICE

Boston, Mass. and London, England
Miami, Fla. and Brasilia, Brazil
Miami, Fla. and Johannesburg, So. Africa
(Repeatered at Brasilia, Brazil)
New Orleans, La. and Santiago, Chile
New York, N. Y. and Bonn, Germany
Oakland, Cal and Honolulu, Hawaii
Oakland, Cal. and Sydney, Australia
(Repeatered at Honolulu, Hawaii)
Portland, Me. and Moscow, Russia
Portland, Me. and Peiping, China
(Repeatered at Moscow, Russia)
Portland, Ore. and Tokyo, Japan
Seattle, Wash. and Yakutsk, Siberia
Washington, D. C. and Paris, France
Washington, D. C. and Bombay, India
(Repeatered at Paris, France)

TYPICAL GROUND STATION INSTALLATION FOR COMMUNICATION SATELLITE SYSTEM
(Operating on One 500 mc Band)

ITEM	Number Required	Estimated Cost
Transmitting Antenna, 60-ft Dish Commercially available—presently used for missile tracking, etc.	2	$600,000
Receiving Antenna, 50 x 50-ft Horn Will be a scaled up version of the TD-2, TH horn-reflector antenna.	2	800,000
Beacon Tracking Equipment Commercially available—used frequently with missile tracking.	2	200,000
Transmitter, 1 KW Commercially available—nothing new—may require some improvement in stability.	3	300,000
Maser Receiver Developed by B. T. L. a few years ago—further research and development required to obtain 100 mc bandwidth—this is believed to be feasible.	3	150,000
Emergency Power Equipment Commercially available.	—	150,000
Land and Building	—	200,000
TOTAL COST	—	$2,500,000

The cost of multiplex equipment is not included inasmuch as such equipment is essentially common to all plans.

Near-Future Demands — Judging from present growth, by 1980 telephones in the U. S. will increase to 235 million (three times today). Similar trends are evident for world telephones and overseas messages. The growth potential outside the U. S. indicates about 265 million, or about 7 telephones per 100 population by 1980. Adding the 235 million calculated for the U. S. gives a world total of 500 million telephones in 1980. Likewise, the trend in overseas messages shows that we can expect some 100 million overseas messages in 1980. IT&T believe that the past performance and the new opportunities for expansion make these estimates worthy of serious thought. This growth would require about 10,000 message circuits to handle the estimated traffic in 1980.

Military Implications—Even today, global communication to control military bases and operations is assuming special importance. The quick reaction time of current weapons and swift intelligence stress the need for infallible broadband communication systems. Possibly, communications between tracking stations on Earth, needed for space exploration may ultimately depend on use of satellite communication.

Long-Range Picture—Estimates place the world's population at over 5 billion in the year 2000. There would be over 1½ billion telephones and several billion messages handled between the U. S. and overseas points. This would require well over 200,000 circuits or better than an average of 15,000 circuits for each of the 13 main areas served under the plan described earlier. Television requirements could also be expected to increase three or fourfold during this period.

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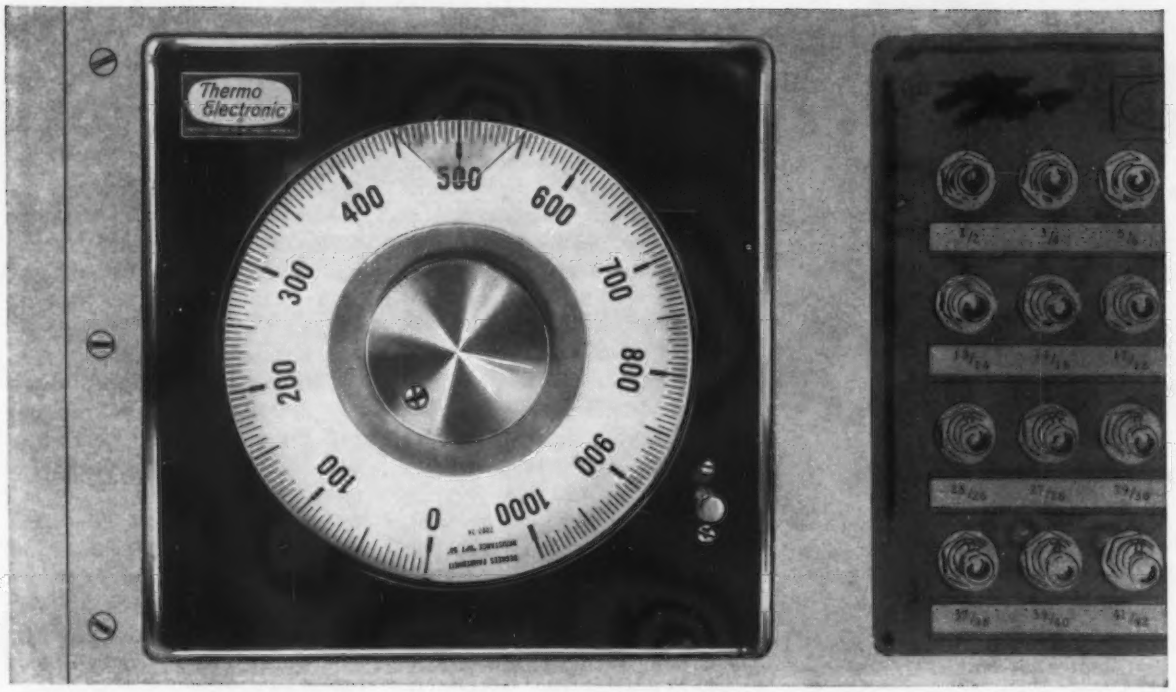

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ARMY AVIONICS . . .

Procurement Patterns and Forecast

- *Up to thirty per cent of flyaway cost on Army aircraft is for avionics.*
- *Here is how Army's requirements grow into usable hardware.*
- *Total procurement will peak at $49 million in next decade.*

by C. P. Page,
Market Research Analyst
Motorola Inc., Electronics Div.

To know your market, you must know your customer. You must know who he is, how he buys, what he buys, and when he buys it.

In the Army avionics market, CONARC (Continental Army Command) is the user and is thus the basic customer.

The things CONARC buys are born in QMR's (Qualitative Material Requirements). Here is how QMR's are conceived and are eventually nurtured through their development cycle to culminate in a tangible, definable market. In the next ten years this market will account for 30 percent of the fly-away costs on at least one class of Army aircraft.

The Procurement Cycle—Originators of QMR's submit them to CONARC. CONARC forwards the QMR to Army's Chief of R&D for evaluation and validation. This evaluation is coordinated with Deputy Chiefs of Staff for Logistics and Deputy Chief of Staff for Operations (DCS/LOG and DCS/OPS) and the Chief Signal Officer (CSO). The Chief of R&D forwards the QMR to DCS/OPS for validation.

The QMR is then returned to CONARC for preparation of Military Characteristics (MC's). The Army Aviation Board at Fort Rucker, Alabama, has the key responsibility for the preparation of the MC's in coordination with the CSO and Signal Research & Development Laboratory (SRDL), Fort Monmouth, N. J.

CONARC now transmits the MC's to The CSO for initiation of

Motorola's Page
". . . know your customer . . ."

Army's Mohawk . . .causing expenditures to peak

a feasibility study. SRDL reviews MC's for state-of-the-art consideration, time frame for development, etc., rather than making a study. A formal feasibility study, if required, is performed by SRDL or industry.

The Technical Characteristics (TC's), which will be reflected in the MC's, are prepared by The CSO in coordination with SRDL, Army Aviation Board, and Army Aviation School. At this stage the MC becomes known as a requirement.

CSO then forwards the requirement to the Army Chief of R&D for approval of the TC's. This approval is coordinated with Aviation Board, DCS/LOG, and DCS/OPS.

The Proposal — The requirement is returned to The CSO for project proposal preparation. Project proposal preparation is coordinated with SRDL and then goes to the Army's Chief of R&D for approval and funding. Project approval coordination is received from Aviation Board, Assistant Secretary of Defense for Research and Engineering (ASDR&E), DCS/LOG and DCS/OPS. Funding is requested through DCS/LOG to implement the project.

The approved development project is next forwarded to The SCO and SRDL to first determine whether GFE will fill the requirement. If GFE is neither suitable nor adequate, a development plan is prepared by SRDL.

Development of the Army Avionics equipment can be performed by SRDL (in-house) or, externally by industry, or a combination of the two. If a mockup showing form and fit is required, SRDL provides it in coordination with Army Aviation Board; Army's Chief of R&D; DCS/LOG; and DCS/OPS.

Equipment is then forwarded to the Aviation Board for User Tests. These tests are performed jointly with Army Airborne & Electronics Board at Fort Bragg, North Carolina, and Army Aviation School. Results of the tests are coordinated with the CSO and SRDL.

Army's Aviation Board submits user test reports to CONARC. CONARC then submits the reports to Department of Army General Staff for review and approval.

After a newly developed item has been approved, the equipment standardization documents are prepared by The CSO for D/A approval. Standardization approval is coordinated with CONARC, DCS/LOG, and DCS/OPS.

After standardization, SRDL and Signal Materiel Support Agency (SIMSA), Fort Monmouth, N. J., prepare the procurement specifications. The CSO and/or DCS/LOG issues the procurement directive. Coordination is received from ASDR&E.

Army Avionics procurement contracts are usually processed by The CSO and/or DCS/LOG.

The contractor that wins the procurement prepares the maintenance manual and spare parts lists with coordination from SRDL and SIMSA performs first article acceptance with coordination from the Aviation Board, SRDL and the Contractor. The Contractor then begins quantity production of the equipment.

Vehicle-Equipment Combine—Now, let us review the relationship between Army Avionics equipment and the aircraft into which it goes. The Transportation Corps is responsible for Army aircraft vehicle specifications. They establish the electronic-equipment weight limitations for all Army aircraft. Therefore the electronic equipment weight, space and configuration limitations are usually established before the Signal Corps defines the electronic equipment requirements.

What Army Needs—Some new Army Avionics equipment requirements that will turn in market items soon are:

(1) A common navigation system possessing improved reliability, weight reduction and simplification of maintenance problems. This system is desired to cover Army helicopters, fixed wing aircraft and ground vehicles. It should provide positive identification in all weather conditions.

(2) A new air traffic control system will be required with the reorganization of the Army's divisions because of increased air mobility. It seems feasible that an automatic data processing system (ADPS) will be one of the important areas requiring new techniques.

(3) New power sources are considered very important with the increased emphasis on weight reductions in aircraft electronic equipment. The use of 400 cycle power is being considered.

(4) New improved tactical ground communications equipment to provide rapid communications between ground elements and aviation elements of combat forces is required. This ground communication set must possess beyond line-of-sight transmission capability.

Ten-Year Forecast—It is estimated that a field army of the future will contain approximately thirty-five air fields, five flight operation centers (FOCS) and fifteen flight control centers (FCC's) from which various types of Army aircraft can operate. These installations will require ground communications and navigation equipment for successful operation of the aircraft.

The forecasts which follow project the procurement expenditures in the years that the Army will award the contract, and not the years which will be covered by these contracts. All years are fiscal.

In the area of **Communications,** a total of $3 million was expended in 1960. This will increase to $14.5 million in 1965 and further increase to approximately $26 million in 1970. A peak expenditure of nearly $27 million is reached in 1968. This peak is caused by the expected leveling of the production of light observation helicopters.

In Navigation, a total of $6 million was expended in 1960. This will increase to $24 million in 1965

and decrease to $11 million in 1970. This decrease is caused by the reduced production of large army aircraft which require complex navigation equipment.

In the area of **Identification, Friend or Foe** (IFF) a total of $260,000 was expended in 1960. This will increase to $1.6 million in 1965 and further increase to $2.6 million in 1970. A peak expenditure of $2.9 million is reached in 1968. This peak is caused by the expected leveling of the production of light observation helicopters.

In **Radar,** a total of $2.5 million was expended in 1961. This will increase to $3.5 million in 1965 and decrease to $1.5 million in 1968. A peak expenditure of $7.5 million is reached in 1962. The peak is caused by the expected number of AO-1B Mohawk aircraft to be produced during 1962.

The **Infrared** market is estimated at over $1 million in 1963. This will increase to $2.5 million in 1965 and decrease to approximately $1.5 million in 1968. This decrease is due to completion of the Army's requirements for AO-1C Mohawk aircraft.

Total Procurement Expenditure for Army Avionics was over $9 million in 1960. This will increase to over $45.5 million in 1965 and decrease to approximately $39 million in 1970. A peak expenditure of over $49 million is reached in 1967. The decrease is caused due to completion of the Army's requirements for heavy aircraft, and decrease in navigation, radar and infrared equipment requirements.

Research, Development, Test and Evaluation (RDT & E) totaled approximately $17.25 million in 1960. This will increase to $12 million in 1965 and further increase to $22 million in 1970. A continued increase in RDT & E is forecast.

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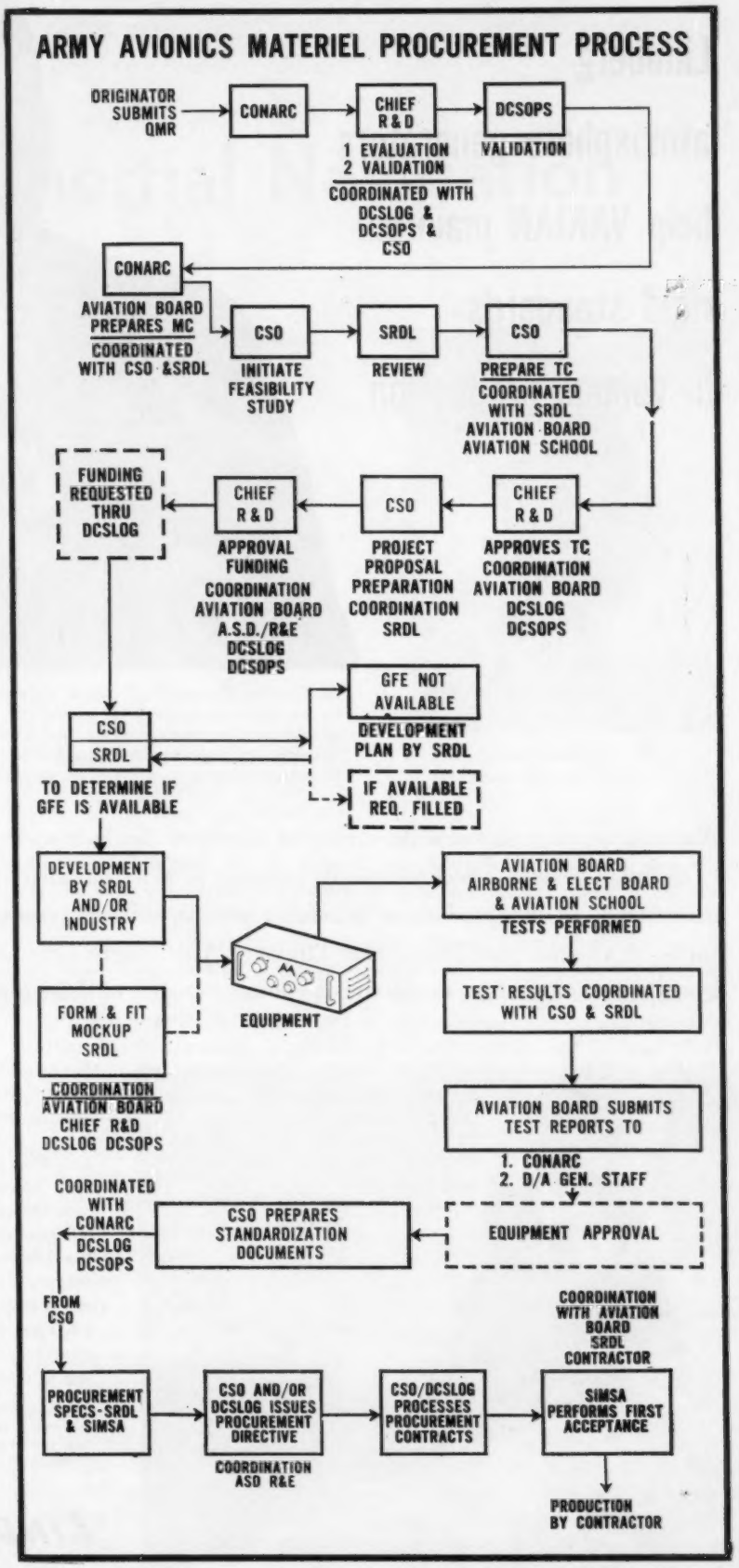
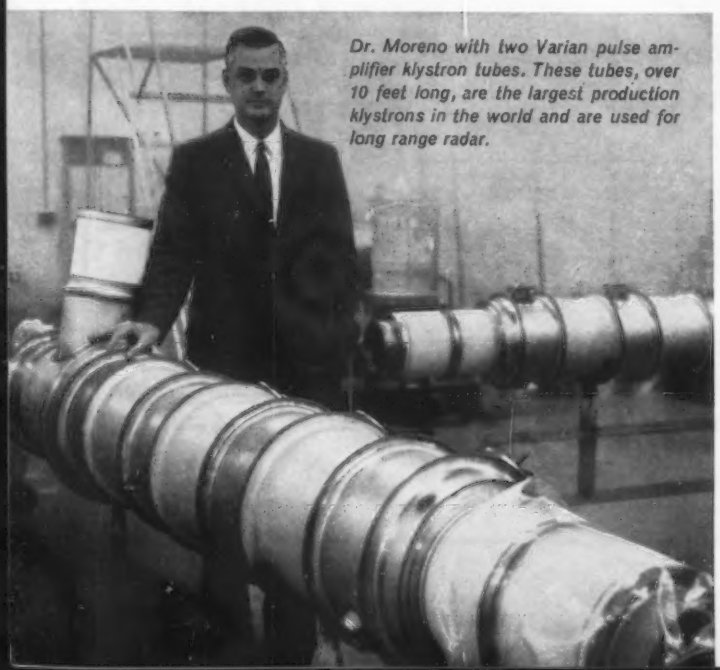


Lindberg atmosphere generators help VARIAN maintain rigid standards in volume production

Dr. Theodore Moreno, Vice President, Tube Division, Varian Associates, Palo Alto, California. Varian Associates is one of the country's foremost producers of equipment for a wide number of fields such as communications, navigation and aircraft control, advanced defense systems including early warning radars, and missile guidance, detection and ranging. Many Varian developments represent important advances in electronic technology.

QUOTE from Dr. Moreno

"Varian's success in the wide variety of electronic fields it serves depends not only on its ability to develop a technologically superior product but also on the development and maintenance of the production standards and capabilities required to retain this superiority in volume production. Our Lindberg Atmosphere Generators are making an efficient and dependable contribution to the consistent maintenance of these highly precise production standards."



Dr. Moreno with two Varian pulse amplifier klystron tubes. These tubes, over 10 feet long, are the largest production klystrons in the world and are used for long range radar.

Four Lindberg Atmosphere Generators are used at Varian Associates to provide dissociated ammonia atmospheres used in the production of microwave tubes. These include units with 1000 cfh, 2000 cfh, and 4000 cfh capacities. Varian also uses five Lindberg Furnaces for various research and production requirements. Lindberg has pioneered in practical equipment for producing all types of atmospheres for the treatment of metals and ceramics. If your product or processes need the application of atmospheres talk it over with Lindberg. Call your Lindberg Field Engineer (see your classified phone book) or write us direct. Gas Process Division, Lindberg Engineering Company, 2473 W. Hubbard St., Chicago 12, Ill.

Los Angeles plant: 11937 S. Regentview Avenue, Downey, California. In Canada: Birlefco-Lindberg Ltd., 15 Pelham Ave., Toronto 9, Ont. Also, Lindberg plants in Argentina, Australia, England, France, Italy, Japan, South Africa, Spain, Switzerland and West Germany.

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Trends In Inertial Navigation

- *In both optical-inertial and inertial techniques mechanics are being simplified while increasing burden is placed on solid-state electronics.*
- *Breakthrough needed in altitude sensing devices.*

by John Slater, Staff Engineer
Inertial Navigation Dept. Autonetics Div., NAA

Navigation Specialist Slater
. . . physicists moving in . . .

Mis-navigation in a crowded airlane can cause a major disaster. Mis-navigation of a single missile can precipitate a war.

Accuracy and reliability demands are extremely high in military and civilian navigation equipment. Yet dependability must be achieved at a reasonable cost. There are many other critical items besides navigation systems to be fitted into the budgets of military and civilian customers.

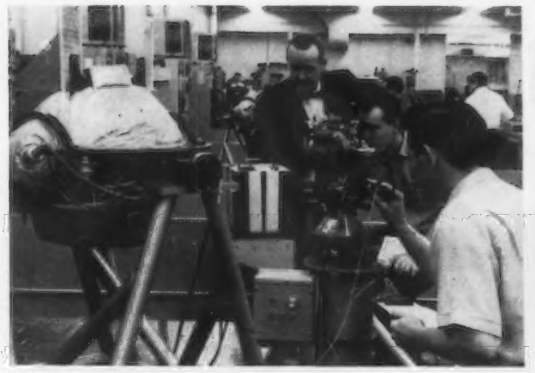
In the U. S., in the inertial and inertial-optical fields, one line of attack on these problems is simplifying mechanism and structures and putting as much as possible of the burden on electronics. The situation is analogous to the much-publicized case of "molecular electronics." The traditional wired-up collection of vacuum tubes, resistors, capacitors, etc., in this case is being replaced by closely integrated complexes of solid-state elements. As with electronics, inertial navigation science and technology is in such a condition of flux and transition, that only general predictions can be made about the future.

Inertial Methods—The inertial method of navigation depends on gyros to establish a directional framework of reference. Accelerometers stabilized by or referenced to the gyros, and integrators and computers (including a gravitational computer) determine velocity and position in a selected coordinate system.

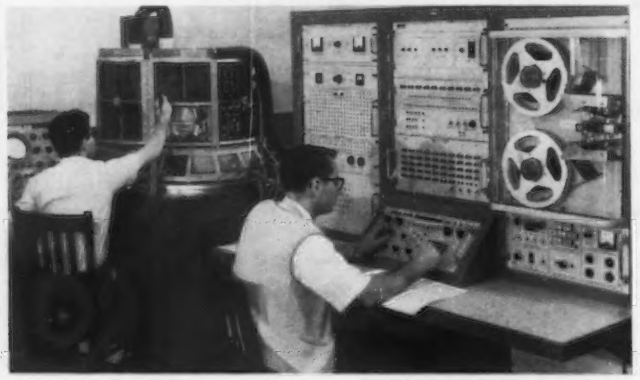
Present practice is to keep the platform-stable element (gimbaled gyro and accelerometer assembly) in some predetermined orientation relative to Earth. This is done by application of gyro control torques. With increasing refinement in the inertial components and computer, the practical need for keeping a platform-stable element in a definite orientation relative to Earth may disappear. Eventually even the stable element may be done away with, for some applications—gyros and accelerometers being fastened to the airframe, and the computer, taking signals from these instruments, as its inputs, keeping track of maneuvers (and of time) and resolving sensed accelerations into horizontal and vertical components by computation. The formidable instrumentation problems in such systems are under attack in several current programs.

New Gyros—Development of gyros and accelerometers has broken away from the classical machine-design approach. Gyros based on ball bearings and gimbals, which long dominated the field, are yielding to competition. Gyros produced by one manufacturer, utilizing gas-lubricated rotor spin bearings, are in operational use, and other manufacturers have announced their intention to replace ball bearings by that type. The designs take advantage of the extreme rigidity and virtual absence of vibration which the rotor spin bearings offer.

All gimbaled gyros are meeting competition from the so-called free-rotor type, wherein the rotor is given all three degrees of freedom by a spherical bearing. So far only the autolubricated gas-bearing type of free-rotor gyro has found operational use. Instruments based on



Theodolites are read by technicians while S. Fred Eystone, vice president and general manager of Inertial Navigation Product Div., Autonetics watches alignment test on GAM-77 (Hound dog) inertial autonavigator.



Solid state digital computer (left) not only directs Minuteman during flight, but checks and calibrates guidance during silo storage. Digital computers have virtually replaced analog types.

electrostatic and magnetic field supported spheres spinning in vacuo are in early stages of development. Principal problems in free-rotor gyros are in providing nearly perfect geometry, high stability of materials, and critical surface structure and finish. In magnetically supported gyros the electrical and magnetic properties of the rotor material in bulk are likewise critical. Solution takes gyro design more and more into the province of solid-state physics and molecular engineering. Certain radical gyro (or inertial-space-reference) approaches seek to avoid altogether problems associated with macroscopic machines in bulk by utilizing the inertial properties of atomic nuclei.

Accelerometers—As for accelerometers, the costly and complicated gyro pendulum as originally used in the German V2 rocket is giving way to devices which perform the sensing and integrating function in simpler ways. The new accelerometers are the induction type based on use of a conductor-and-magnet tachometric coupling, and instruments based on acceleration-sensitive (mass-loading) vibrating ribbons and force-balance type accelerometers with electrical circuits to provide a digitized output. All such devices pre-suppose a high degree of constancy and stability of materials and circuit elements at the molecular level.

Computers—The digital type of computer has virtually displaced analog types for inertial navigation. In addition to improving accuracy it has made possible simpler stable platforms and components, which no longer are required to perform analog-computer functions. Emphasis is on core-type or other solid-state memories as distinguished from devices based on moving parts.

Inertial navigation systems are in routine operation in many submarines and large ships of the Navy; they are also provided in some missiles of airborne type. Practically every known long-range ballistic missile utilizes inertial guidance. Civilian applications, marine and aeronautical, are dependent on meeting requirements as to size, power and cost.

Optical-Inertial—Star trackers, for monitoring inertial navigators, are the subject of active development for terrestrial as well as for extraterrestrial navigation. Extreme compactness is required. Principal lines of development include:

(1) Telescopes with multiple internally-reflected light paths for maximum compactness.

(2) Miniature solid-state photosensitive devices as alternatives to the much-used photo-multiplier.

(3) Investigation of various spectral regions especially the infrared.

(4) Non-mechanical angle measuring devices of inductive, electrostatic and optical types.

Altitude Measurement — Attention should be called to the unsatisfactory state of the art of vertical distance (altitude or height) and rate of change thereof. Only the inertial method can make such determinations accurately and the unbounded nature of the error function restricts such method to short-period guidance operations as in the case of rockets. A "breakthrough" is needed.

Forecast Summary — Inertial navigation is spreading out from the province of classical machine design and circuit design, into that of solid-state physics and "molecular engineering."

The sort of training required of scientific and engineering personnel, and likewise of many technician and factory personnel, is quite different from that required a decade ago.

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Management By Computer . . . . . How and When?

- *Is the computer-based management system a trend for the 60's?*
- *What organizational changes must be made to integrate a computer into the decision-making process?*
- *Can the computer actually replace managers?*

Read This Analysis . . .

by Dr. Allan J. Rowe,
Mgr. Industrial Dynamics Research
Hughes Aircraft Co.

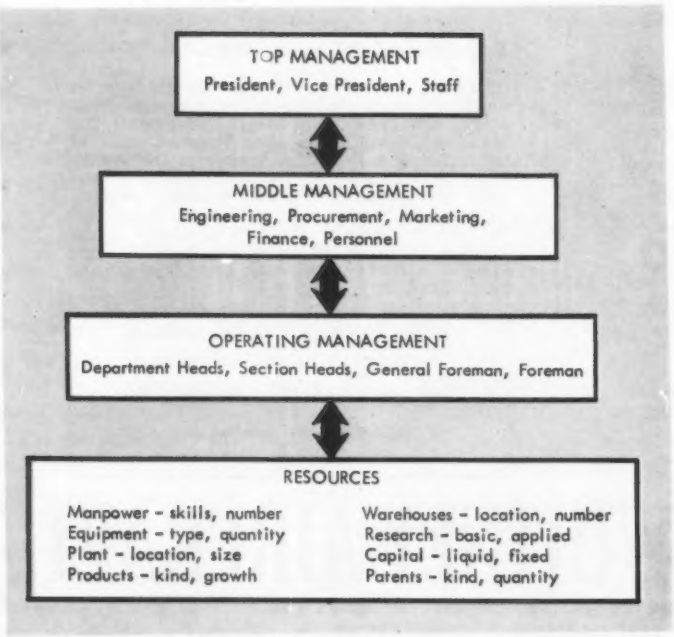

FIG. 1. Management is the custodian of a company's resources. The various authority levels in management are linked to the resources by information flow.

How deeply will computers cut into the decision making processes once reserved for management? Some feel that machines which started out as man's tools threaten to replace him. They point to operating management and say it already bears the scars of the computer. Middle management, they say, is next. This group has highly organize itself and its functions, and this is the kind of environment in which computer techniques flourish.

But do the facts really bear this out? True, the computer-based management system is upon us. And the computer will play a big role in operating and middle management. But, says E. B. Arbuckle, Dean of the Graduate School of Business, Stamford Univ., the real managers will never be replaced by machine. These men will only find more ways of using the computer and other management tools so

Management Researcher Dr. A. J. Rowe

Why does management exist?

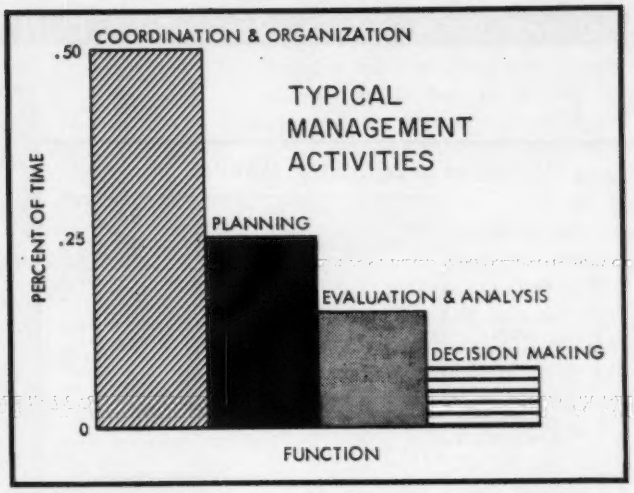

FIG. 2. Major time consumer for management is coordinating and organizing other managers. The time spent in evaluating and analyzing data is where the computer can help. It will allow more time for decision making.

that they themselves might manage more effectively. Now, how?

Analysis—Before decision making processes on any level can be reduced to formula, management activities have to be thoroughly studied, defined, and reduced to quantitative terms.

Why does management exist? What does it do? When and how does it do it?

Although much energy has been expended in attempts to define the "raison d'etre" of a business, suffice it to say that businesses do exist. And, unquestionably they have purposeful objectives. It can hardly be argued that managers of such businesses are custodians of the resources and as such are responsible for the survival of the business. To the extent that these considerations can be formalized, the role of the computer in the management of the business can be explored.

Information Flow—Think of the relationship of management to the business resources as shown in Fig. 1. First, there are various authority levels within the management structure. The number of levels has an effect on the speed and accuracy of information transmission. This is an important aspect in understanding the characteristic behavior of decision makers in response to information flow. Management is linked with the resources of the business via information flowing through a communications network.

Characteristics of the information flow among managers and between the managers and operations provide one of the basic measures of system behavior. Since information and decisions are normally transmitted serially from the top down, the coupling of management with the resource is inversely proportional to the authority level. Thus, computer-processed information could provide the means for more effective implementations of the decision-making function by more accurate and timely dissemination of information.

An analysis of the points in a system where decisions are made and the informational requirements for the decisions provides a first estimate of the communication network. An aggregation of information flows up to top management. In any actual business, much of the information is not pertinent to the direct operation of the business. And, informal communication channels often provide useful information. Nevertheless, the precise informational requirements are bound to have an impact on the organizational structure of the business.

In a sense, the decision maker has surveillance over a given number of decisions points, which, when linked to other decisions points, define the underlying operational structure of the business. Thus, an organization can be viewed as an information and decision-processing medium.

Decision - Making Function—Looking at the typical activities of management (Fig. 2), one finds that half their time is spent with other managers or subordinates. Of the remaining 50 per cent, approximately half of the time is spent in planning. The remaining 25 per cent is spent in analysis and evaluation of information as the basis for decision making. It is this latter percentage of the manager's activity which may be amenable to use of computer-processed information.

The decision-making function in a typical organization, is shown in Fig. 3. At the top management level, the decisions are concerned with directing the organization and

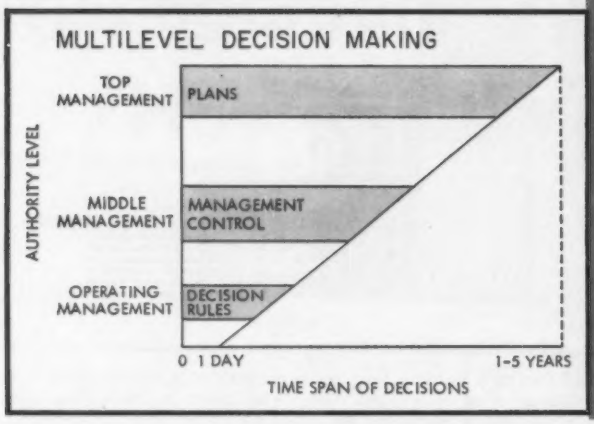

FIG. 3. Top management's decisions are often influenced by intuition and experience. Computers can't fill this role. Middle managements function, however, is control. This is where the computer is used.

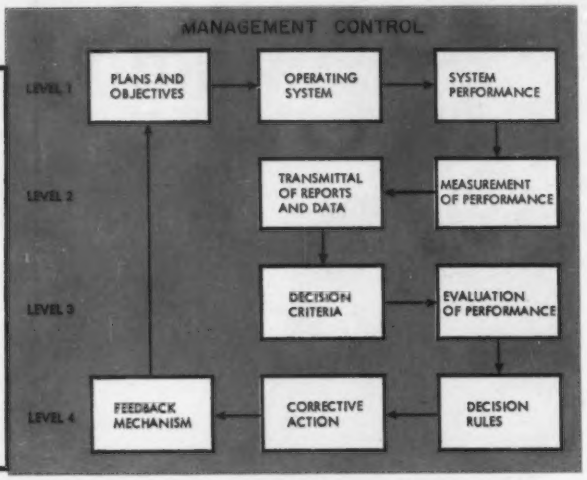

FIG. 4. The specific tasks in middle management where the computer can be applied are: Measurement, Reporting, Evaluation, Decision Rules, and Feed back.

providing means of assuring its survival. To achieve maximum effectiveness at the operating level, plans and policies must be applied to the available resources, subject to specified constraints and risks. However, there is generally insufficient information for these decisions, and they cannot be structured as a set of procedures. But, most important, policy decisions are often based on a blend of intuition, experience and emotion. It hardly seems possible to automate these decision bases.

Man In The Middle — Middle management's function is control. And the computer can be used in certain well-defined aspects of this activity. The management control process can be illustrated as in Fig. 4. The measurement, reporting, evaluation, decision rules, and feedback are susceptible to computer processing. However, the decision criteria, plans and objectives are still subject to human judgment.

At the operating level, where the physical processes in a system are applied, there is the highest opportunity for computer application. Numerous examples exist of automated data processing, especially in production and inventory control and accounting. Examples of decision rules applied to physical processes can be found in the Journal of Operations, Research, Management Science, and Journal of Industrial Engineering. In all these instances of automated data processing, supervisors are still required to deal with the workmen who actually operate the processes. The conclusion seems to be that specific data processing activities can and have been automated, yet management still performs the basic decision functions

Decision Rules—There is clearly the need for formalized decision making in management.

Although there are many ramifications to management decision making, the following aspects of decision making should be considered in a computer-based system:

(1) The bases or criteria for making decisions.

(2) The information required to make decisions.

(3) Where decisions are made and by whom.

(4) The number and type of decisions made at various organizational levels.

(5) The response rate required for decisions after information is received.

(6) The time taken to actually make the decisions.

(7) The induced lags or delays in information flow due to decision making.

(8) The noise or errors in the decision-making process.

(9) The relation of organizational structure to decision making.

(10) The bases for automating decisions.

Although this list is only partial, it indicates the kind of problems confronting the use of computers in management decision-making. Behavior and motivation characteristics of decision making, although not considered, are nonetheless extremely important factors.

The Integrated Business System —In order to implement a computer-based information system for management decision-making, it is necessary to view the business system in a new light. It must be thought of as an integrated whole, directed at purposeful objectives.

A schematic diagram representing the business system as information flows among various functions and activities in a typical manufacturing (resource transforming) business is shown in Fig. 5. At the heart of the system is the decision-com-

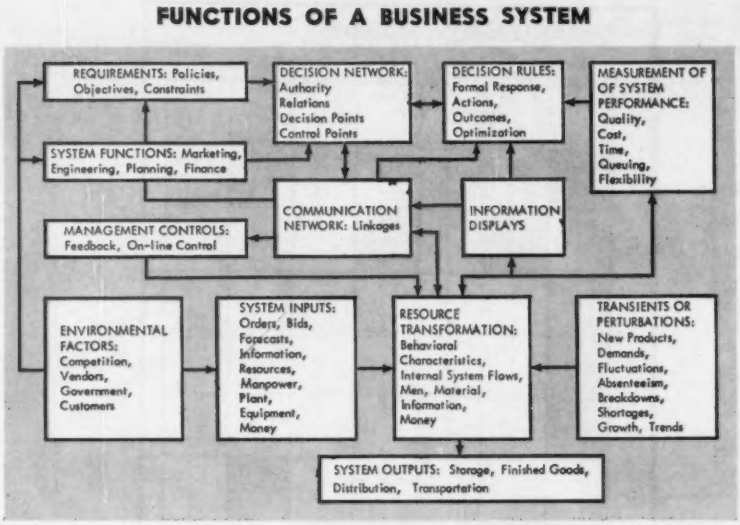
FUNCTIONS OF A BUSINESS SYSTEM
REQUIREMENTS: Policies, Objectives, Constraints
DECISION NETWORK: Authority Relations Decision Points Control Points
DECISION RULES: Formal Response, Actions, Outcomes, Optimization
MEASUREMENT OF OF SYSTEM PERFORMANCE: Quality, Cost, Time, Queuing, Flexibility
SYSTEM FUNCTIONS: Marketing, Engineering, Planning, Finance
COMMUNICATION NETWORK: Linkages
INFORMATION DISPLAYS
MANAGEMENT CONTROLS: Feedback, On-line Control
ENVIRONMENTAL FACTORS: Competition, Vendors, Government, Customers
SYSTEM INPUTS: Orders, Bids, Forecasts, Information, Resources, Manpower, Plant, Equipment, Money
RESOURCE TRANSFORMATION: Behavioral Characteristics, Internal System Flows, Men, Material, Information, Money
TRANSIENTS OR PERTURBATIONS: New Products, Demands, Fluctuations, Absenteeism, Breakdowns, Shortages, Growth, Trends
SYSTEM OUTPUTS: Storage, Finished Goods, Distribution, Transportation

FIG. 5. To use the computer in management decision making, the business structure must be viewed as an integrated whole. The decision-communication network is at the heart of the system.

munication network, which is normally thought of as the management function. The decision network (Fig. 2) is linked to the resource transformation or operations subsystem through the various organizational levels of authority.

To be amenable to computer-processed information, the various activities, flows, responses, and behavioral characteristics within the operations subsystem must be defined. Information on the performance of subsystems can be presented in the form of displays for use in conjunction with formalized decision rules. Specific data, reports, or summarizations which measure system performance can also be presented. There should be flexibility in the manner of summarizing information, as well as frequency of reporting and communication links. Other inputs to the decision network should include the system constraints or policies, system functions, and environmental factors. These, too, would be represented by flows of information via the communication network. Structuring a business in this manner, the basis is provided for eventual computerization of information flow and formalized decision making.

One means of representing information flow is the use of matrix notation. To illustrate the manner in which this can be employed, a simplified hypothetical organization can be used to represent typical functions in a business enterprise (Fig. 6). Department heads B, D, E, and F report directly to the manager A. Purchasing C reports to B and Personnel G reports to Finance F. These are similar to conventional authority channels; however, as shown, they do not represent the dynamic interrelationship of these functions.

On the other hand, we can portray various alternate relations as a function of time, urgency, or decision criteria. For the present, let us represent this conventional organization chart in the form of a matrix as shown in Fig. 7. Thus, as was shown in Fig. 6, B, D, E and F report to A, and C reports to B. Note the ease of showing where all the persons report by merely placing x's in the matrix and also the possibilities of modifying these relationships. Informal or secondary channels can be represented by other letters such as y. Thus, for example, purchasing may report informally to the engineering manager and is shown by the Y.

In a similar manner, matrix format can be used to indicate information flow, material flow, etc. For example, a formal information flow pattern might be as shown in Fig. 8. The numbers shown inside this matrix indicate the sequence of information flow through the organization, as well as the originator of the document. Special codes such as zero can be used to indicate that the document or data originated outside of the system.

The letters alongside the matrix, $D_1 \ldots D_n$, are the coding to identify specific information. This may be a telephone call, a sales report, a customer order, absenteeism report, etc. In this way, the communications network can be formalized. In addition, informal information flow can also be incorporated into the matrix.

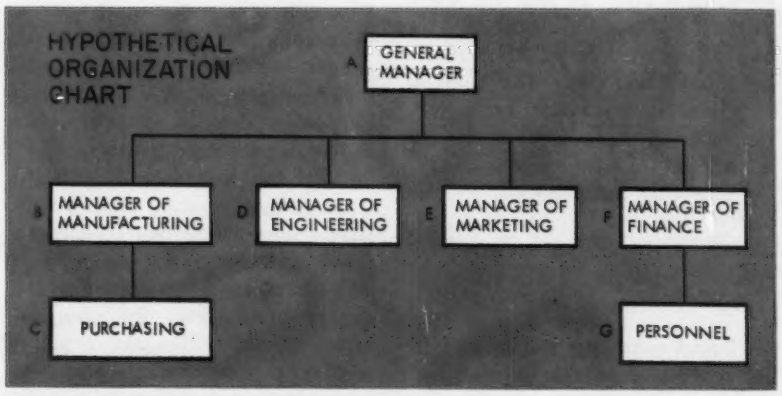

FIG. 6. The company organization chart alone can never be used to study information flow. It is not dynamic.

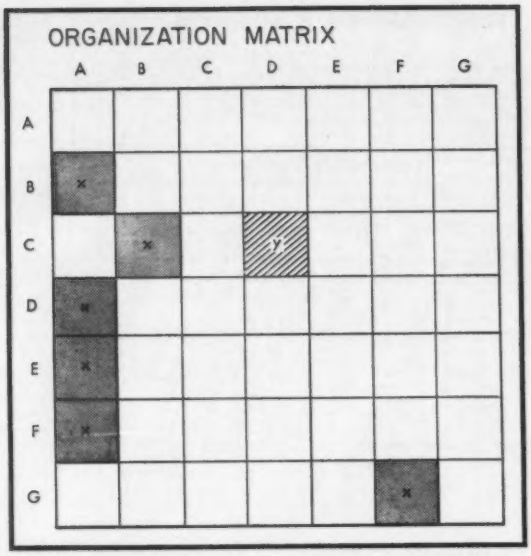

FIG. 7. A matrix can be set up to better depict how information flows between managers. Primary flow is indicated by "X," secondary flow by "Y."

This matrix arrangement can also be used to represent raw data or system status. Referring to the matrix in Fig. 8, the general manager, A, may issue a directive, D_1, to his department heads (who are all presumed to receive the communication simultaneously) and they, in turn, may be expected to take appropriate action. This directive, in effect, causes a decision to be made by each of the department heads. The basis for their decisions and the consequent actions should all be part of a computer-based system.

Another type of information flow is shown opposite D_4. Here the general manager receives information on the market position of the company and forwards this to the marketing manager. However, the dynamics of this situation must be considered to assure realism. For example, how soon is the information transmitted and how long is it before the marketing manager takes appropriate action? These are some typical questions which should be considered in a computer-based system.

Still another kind of information flow is shown opposite D_5. The manager of manufacturing notifies personnel that there is a shortage in a given skill category and that hiring should proceed. The zero in the box opposite D_5 is now used to indicate that this information is a result of the system performance. Thus, as data are summarized and made available at various points they become inputs to the information flow. The kind of data, manner of summarization, and frequency of reporting are all part of the information flow analysis. By providing for variations in the pattern of information flow, it should be possible to examine the effect of changes in reporting on system performance.

Decision-Making Model — For our purpose, we can conceive of the decision-making process as consisting of the following elements:

(1) A triggering or forcing function which initiates the process.

(2) Decision criteria which provide the basis for response.

(3) Decision rules which provide formalized response as a function of variable input.

(4) Action actually taken as a result of the decision process.

(5) Outcome or result of the actions on system performance.

(6) Feedback to correct decision criteria or decision rules.

One aspect of the problem is predicting exact response of human behavior for a given stimulus. Certain behavioral or motivational aspects of the problem can be subsumed by variability in the above elements of decision making. However, it must be recognized that formalized organizational relations and motivation directly alter or affect the decision-making process.

To establish logical relationships, critical events are used to trigger information flow to decision makers. Suppose, for example, a part completes its processing in the factory and is ready for assembly. When it reaches this state of completion, the information could be transmitted immediately to various decision points. Or, the information processing system may be such that at the end of each day Production Control is the only one notified as to which parts have been completed. They, in turn, might take certain action depending on the state of completion of mating parts. Thus, a logical comparison as a basis for decision making might be made as follows:

(1) Is part A complete? Yes.

(2) Is part B complete? Yes.

(3) Is part C complete? No.

If the assembly requires all three parts, then the answer—yes, yes, no—would lead to a different decision than three yes's. This can be represented as follows:

(1) Part A has been completed. What decision should now be made?

(2) Determine completion status of mating parts.

(3) If all three are completed, proceed to assembly.

(4) If any component is not completed, place parts into an accumulation area.

(5) Repeat the check on status of mating parts after a suitable time interval.

The various specific decisions, or classes of decisions to be made at decision points can be represented in tabular form, and the computer could determine where

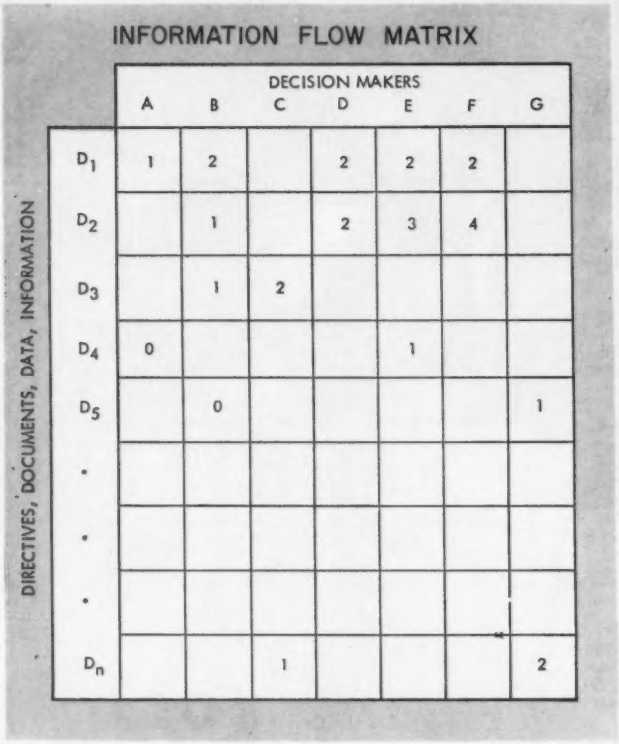

FIG. 8. A more comprehensive matrix shows specifically the sequence of information flow. Letter code corresponds to Figs. 6 and 7.

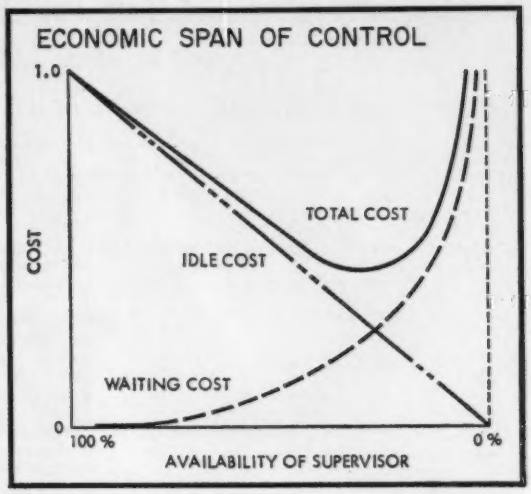

FIG. 9. The supervisor is a decisions processor, as well as a director of subordinates. There is an optimum mix of these two functions from cost standpoint.

the decisions should be carried out. This search technique can be simplified by using the logical characteristic of computer operation.

Thus, for example, Table 1 shows two triggering functions which initiate the decision process. The first function is a result of a change in the system status. The second function is the result of a formal document requesting the purchase of some raw material. The logical considerations and action to be taken are shown in Table 1.

It is obvious from Table 1 that a logical comparison implies a yes-no response. An important advantage of this method of comparison is that computers operate in a binary or yes-no mode so that this approach simplifies the computer programming as well as formalizing response to avoid ambiguity.

This logical format for representing the decision-making process is especially useful in studying problems involving a number of interacting elements. For instance, the disposition of a part for assembly was made contingent on the status of the mating parts. It is the computer's ability to update and store considerable information which permits handling these considerations in such detail.

Time Lags—A significant aspect of the problem is the time phasing for contingent decision. The flow of information can introduce time lags into a system as a result of queueing effects. In a sense, information flowing through a number of decision makers is comparable to jobs flowing in a factory or cars flowing on the highways. For example, if the decision maker is viewed as a processing center, the rate of arrival of decisions and the time taken to make the decision will determine the average delay or queuing effect. If appropriate priorities are assigned the various decisions to be made, it is possible to both improve effectiveness and reduce delay times.

For a given type decision, given organization structure and given cost, there are alternate response rates which are optimal. The faster the response, the greater the system effectiveness since time lags seriously hamper performance. Of course, speed of information flow is not a sufficient criterion of usefulness. The right information, in an understandable form and free from errors.

A more thorough analysis of the kinds of decisions made should yield insight as to where the computer can aid the decision maker. Routine decisions involving a large quantity of data can most easily be automated. Complex decisions involving judgment and analysis could use computers to digest information, evaluate alternatives, and test key parameters as aids in decision making.

Organizational Problems — An organizational problem related to decision making is span of control. Decentralized organizations require increased supervision of people, since there is a greater possibility of distortion and error in information transmission as the number of levels in an organization increase. A cost function which relates decentralization or numbers of levels of supervision and centralization requiring automated information processing, would be an important consideration in introducing computers. For example, consider the organi-

TABLE I

DECISION TRIGGERING AND RESPONSE

Decisions Normally Made at this Point—Trigger Function	Logical Considerations or Decision Criteria	Action to be Taken or Decision Rules
1. Part reaches completion status.	1. Review all mating parts to be completed.	1. If all mating parts are completed, send to assembly. 2. If one or more parts have not been completed, send this part to accumulation area.
2. Request for raw material.	1. Review order point.	1. If order point has been reached, check forecast usage— a. If forecast usage is the same, compute the economic order quantity and send order to purchasing. b. If usage has changed, send a request to engineering for further information.

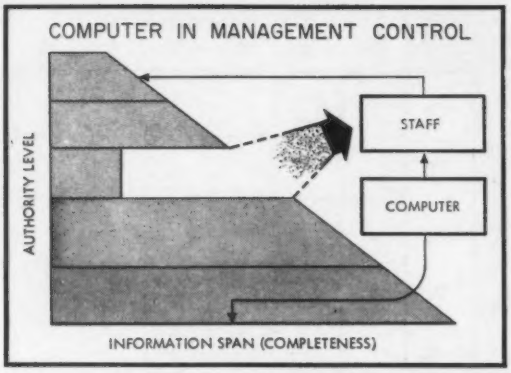

FIG. 10. Middle management could become as staff function, processing computer outputs, in the "computerized" management system. The current type of organization structures do not lend themselves to computer-based systems.

zational aspects of supervisory span of control. Rather than have an arbitrary number of persons that can be supervised, the arrangement of work content and number and kind of decisions should have a direct bearing on the problem.

Since the supervisor is a decision processor, an economic span of control could be determined as shown in Fig. 9. If the supervisor is always available (no subordinates), there would be a high idle cost; however, if there were too many subordinates, decisions would be held up due to the supervisor being unavailable. This leads to a high waiting cost. Thus, the correct span of control would consider the cost of delays in decisions on the entire business. Since the waiting or queueing effect increases exponentially, it appears that there is an optimum availability of the supervisor which can be related to the span of control.

Recentralize Management—An important question is the impact of computers on the organization structure. Computers may lead to recentralization of organizations, with information flows providing the basis for design.

Stated another way, to provide effective direction, there is the need for centralized control; while to provide for motivation and growth, there is the need for decentralized decision making. There appears to be an unfortunate inability to distinguish decision making at the operational level from control at the top executive level. To illustrate, funds available for budgets are determined at top level; whereas detail procedures for producing results should be determined at the operating level. To retain control, however, detail information on performance should be available to top management. One way in which this control may be accomplished by management is to provide a staff function at the middle management level which as direct access to operating data using computers. This can be accomplished as shown in Fig. 10.

The design of a decision network poses a number of formidable problems. Current organization structures lead to a cascading effect of decisions as a result of interpretation at each level and generally differing measures of performance. In addition to the cascade effect among levels, there are the conflicting objectives at any given level. Thus, there is need to treat the problem as a whole rather than the fragmented approach prevalent today. Contrast this with the concept of a systems staff (Fig. 10) reporting to the top executive which acts as the summarizing mechanism using the computer for rapid, random access to detail operating information. In this kind of application the computer would have direct access to all system information and have a large percent reported automatically. Not only is the information on system performance more timely and accurate, but the system staff, as a team, has an overview of the entire operation. Thus, we can anticipate that the organization design in computer-based systems will be more closely matched with the information system's requirements.

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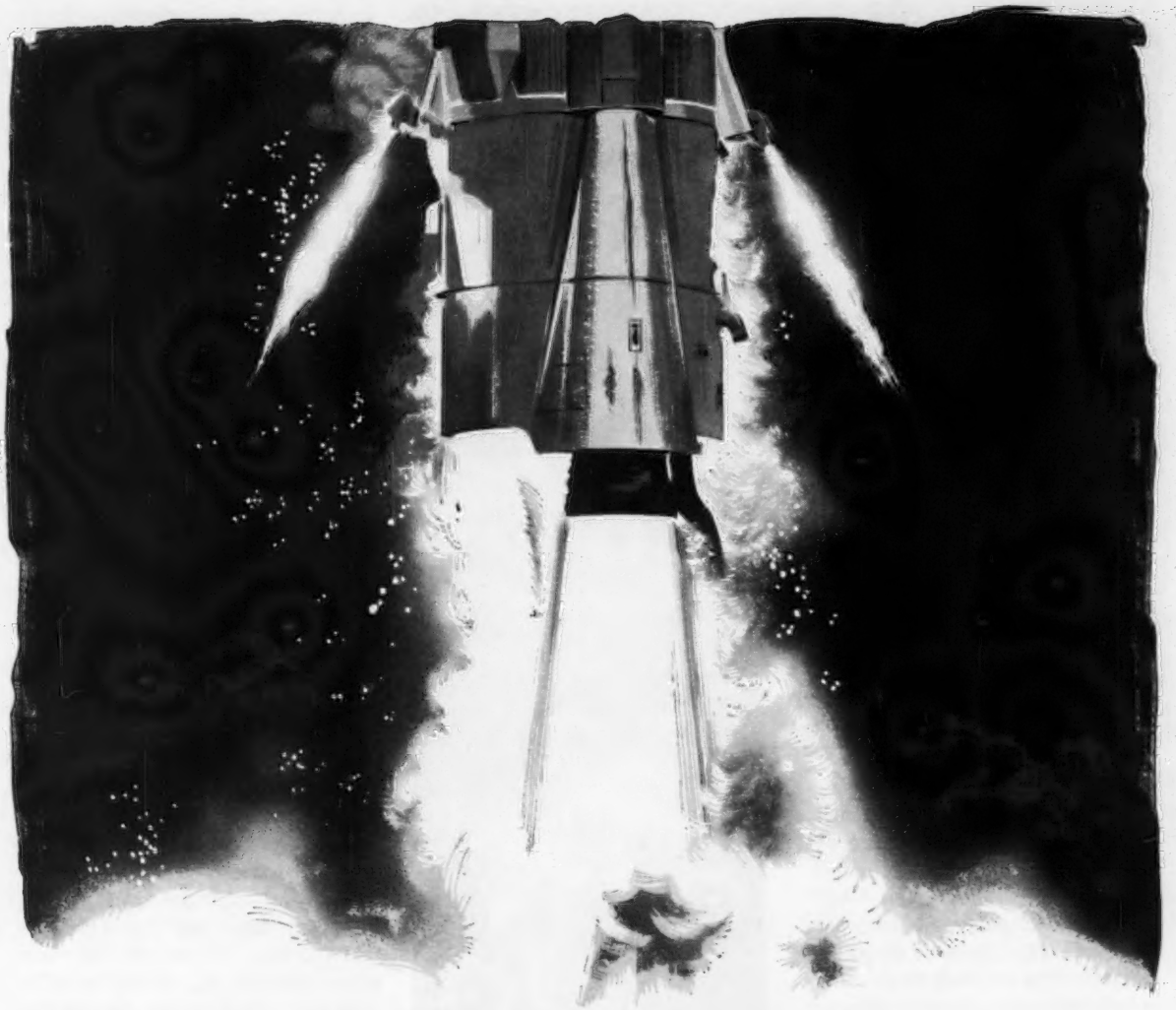

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SCIENTIFIC DATA "Rotting in Storage"

- *Information output doubles every eight and one half years, but much of it lies unused.*
- *Mounting problem is — How to manage this deluge of data as a national resource.*

by Richard S. Leghorn
President, Itek Corp.

Both Russia and the United States now are spending billions annually in an effort to gain supremacy in space. The most immediate returns from these efforts amount to endless streams of information. Yet, in this so-called "Space Age" man's skill to gather scientific data well exceeds his ability to digest and utilize it. The resulting mass of acquired information is growing larger by the day; and unless we learn to use this deluge of data, we are doomed to drown in the very products of our own success.

Let's look at the sums spent for R&D over the past 15 years: $990 million in 1945, $5 billion in 1954, and $13 billion in 1960. Predictions for 1970 now run close to $30 billion.

In 1960, these R&D dollars generated 60 million pages of technical reports. These reports were published throughout the world in 55,000 journals, in 60 languages. About 3500 services abstracted and indexed the contents. In the U. S., 14 major services prepared 600,000 abstracts and title listings. This was 19 per cent ahead of 1958, but still far behind the rate of increase in technical literature.

Our present rate of massing scientific data is doubling every eight and one half years, and promises to reach 120 million pages long before 1970.

Duplication Waste — A major problem facing the aerospace industries today is how to make this information available to those who need it, when they need it, where they need it. According to a Fortune magazine report, solving this problem could cut ten per cent of R&D dollars now wasted through duplication of effort. A harder-to-define waste, estimated to amount up to half of all R&D money, results from work that would be undertaken differently (and presumably more effectively) or not undertaken at all, if the available literature had been promptly searched beforehand. A typical research worker spends about a third of his time checking on related work. Improved information technology that would reduce by 30 per cent the search time of the worker could increase society's available technical manpower and productivity by ten per cent.

Still another aspect of the information problem is the perishable nature of certain scientific data. This was the case of the Tiros satellite. It took some 22,000 cloud pictures in a matter of a few days; meteorologists for the Weather Bureau took months to interpret them. By this time their value for timely weather forecasting was minimized.

Soviet Efforts — Scientists in both East and West are acutely aware of the information problem.

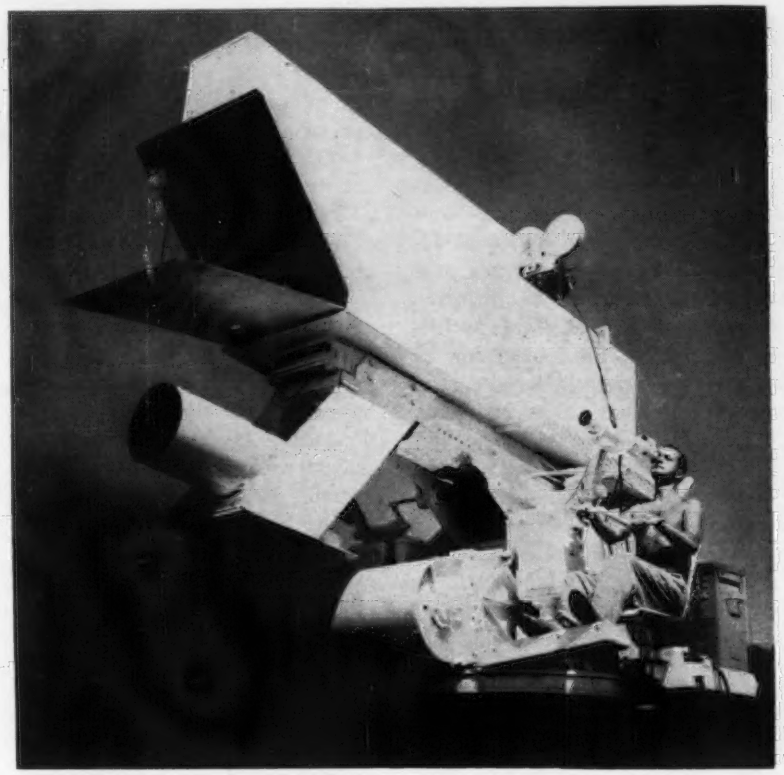
Their approaches to a solution, however, reflect their respective political philosophies. A few months back I visited Moscow in company with Dr. Jerome Weisner, Paul Doty, Walter Rostow and other noted scientists. We had a first-hand look at VINITI, the All-Union Institute of Scientific Information. While they have made progress in machine-techniques, they still depend mostly on manual effort for information processing. Then, too, they are a "closed" society and this seriously impedes information development.

In contrast, the results of our space research are made available to the entire free world.

Let's look at the possible future Soviet challenge in the solution of the information problem. While the composite level of their technical effort is mediocre, their ability to manage technical resources is impressive. They have been able to meet immediate needs for crash programs in line with their professed national needs. Today one can see a vast concentration of their technical efforts on automation, with institutes for automatics and telemechanics in virtually every major city. When the Soviets decide that a technical area is at the heart of their difficulties, or presents a key means to achieve their political goals, they can marshall brilliant and competent technical resources in a most purposeful way.

That the Soviet will soon be, or already is concentrating these resources on the information problem is indicated by their management's strict avoidance of duplication. They copy freely in areas where they do not feel the need to break through. VINITI, which abstracts more than a half-million articles yearly, is a typical example of Soviet readiness to avail itself of the research of others, when they are content to be slightly behind, timewise.

Developments in U. S.—In the U. S., the state of the retrieval art has been advancing steadily in the past decade. Large-scale automated systems are being placed in operation in increasing numbers, both by Government and industry.



Gregorian camera, produced by Itek, has 240-in. focal length. It photographs missile breakaway events, nose-cone and satellite re-entry, and performance.

The U. S. Patent Office's first mechanization effort, Operation HAYSTAQ, is punch-card indexing certain patents in chemistry. This field accounts for 20 per cent of all patents. On the first group to be mechanized, search time dropped 50 per cent, accuracy rose 100 per cent.

Armed Forces Technical Information Agency (ASTIA) is mechanizing a file of 250,000 research reports of projects performed on Government R&D contracts since the end of World War II.

Central Intelligence Agency's Walnut system will be able to retrieve and exhibit any one of nearly 100-million randomly-filed documents within ten seconds.

Both industry and professional societies are likewise making significant headway. Estimates are that some 200 firms, most of them in chemicals, drugs, petroleum, and missiles, have started on mechanized information systems. Dollars budgeted for information in these programs have run from 2 to 3 per cent of total research monies.

The American Society of Metals in its literature center at Western Reserve University is magnetically taping 12,000 metals abstracts a year, making possible searches at the rate of 100,000 an hour.

Language and linguistics have drawn their share of attention. Eleven U. S. teams are working on mechanical translating; some are adapting computers. One group at IBM has developed, for the Air Force, a Russian-to-English translator with a 50,000-word vocabulary on photographic disks. Our efforts at Itek include a project to "normalize" natural language expressions for machine use.

Equipment manufacturers are responding energetically, improvising, inventing, searching basically for keys. The familiar punch-card has taken on new forms such as

the microfilm aperture card, and the edge-notched card.

High-Density Storage—Several manufacturers have gained high-density storage successfully with microphotography, since Kodak pioneered with "Minicard." My own company's "Itekard" techniques have joined the field. Rabinow Engineering is storing information as small holes etched in metal plates. Great strides are now being made in the mechanized handling and processing of graphic as well as mechanical information—data that are acquired and presented in such forms as charts, illustrations, photographs, documents and the like.

Systems to perform these tasks, already in daily use, are being improved through such recent developments as aperture cards, microfiches and the unitized records—or microfilm in individual "chips"—each containing an entire document, or a complete set of associated information.

New developments in optics, photographic emulsions, translucent and reflecting bases, plus improvements in both optical and electronic readout and display systems, will soon provide even greater speed, capacity and flexibility.

But, as great as these advances have been, can they, in themselves, solve the Information Problem? Will this piecemeal approach, admittedly unable to cope with present information needs develop fast enough to meet the needs of a decade from now?

I doubt it seriously. Before we can find a true solution to the information problem, we must first learn to recognize it in its totality. We must stop thinking in terms of a Space Age or an Atomic Age, and start thinking in terms of an Age of Information.

A Management Need — Alert managements already are discovering their critical need for information. A well-known executive recently stated: "to manage a business well is to manage its future; and to manage the future is to manage information."

Or, as a recognized business authority has phrased it: "The impact of the information crisis on the executive will be significant. To an increasing extent a manager's effectiveness will hinge on the quality and completeness of the facts that flow to him, and on his skill in using them. With technology changing at a rapid rate, with the time dimension becoming increasingly critical, and with organizations becoming larger, more diversified product lines, and more dispersed geographically, it is inevitable that executives will rely more and more on formally-presented information in managing their business."

We must realize that information technology is no longer just a supporting function, lost in the limbo of overhead. It is rather, the basis of a vital new industry which is being shaped, whether we like it or not, by the needs and creations of a scientifically-oriented society.

This great new industry already is taking form. From scientific research of recent decades we have discovered new techniques known as "Information Technologies." These are bringing about a reorganization of printing and publishing, library and reference services, data processing, communications, military and arms inspection intelligence, education, and entertainment, into one vast co-ordinated Information Industry—an industry which is cutting across traditional subdivisions—an industry destined to become the largest in modern society.

Approaching The Problem—Technology alone will not solve the information problem. We must also develop new approaches, new methods of thinking. I believe that there are four of particular importance.

- It is fundamental that we as a nation identify and publicize "Information" as a basic national problem, and initiate a coordinated program to surmount it. The Presidency, the Congress, the People must rank Information with the other great tasks we are identifying and are seeking to perform.
- We must continue and strengthen the partnership between science, government and industry to effect solutions to our information problems. This team, so useful in times of military crisis, must soon be harnessed to deal with disarmament, and the economic expansion of undeveloped areas.
- The vast resources of science and technology must be brought to bear on such a basic national problem as that which exists in the information field. While science and technology alone cannot always provide the needed solution, they—with economic and political brains and ingenuity—can find workable solutions as they have done before. Technical resources must be harnessed through the cooperative effort of universities, government and industry before we will have a composite information function fully serving the national purpose.
- We must approach the problem from a unified systems standpoint. We must use the new management techniques developed since the war, to better couple science and technology to deal with business, industry and human problems.

It is not a question, however, of "Can we do it?" but strictly one of "How will we do it?"

The use we make of information within the coming years will determine, perhaps, the future status of science, industry and government in this country. The aerospace industries, holding within it the promise of vast sources of new data, as well as new and exotic means of transmission, may well be the analogue of what may set the standard for all other industries. We can only hope that it will supply the spark to touch off an Information Revolution, the effects of which will be felt throughout the world.

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Next Big Step For PERT

- *Navy-developed management technique has proven effective in development-stage of weapon systems.*
- *Use in proposal stage gaining acceptance.*
- *Techniques now being devised will allow detailed program cost analysis.*

by Roland Frambes

PERT is penetrating new areas in government and industry. Many military projects new require PERT in both the proposal stage and the project stage. Industry is using PERT voluntarily to support proposals. Many firms are investigating PERT with an eye to applying it to marketing, long-range planning, cost and reliability control. They're even PERTing PERT.

PERT (Program Evaluation Review Technique) still considered by many, to be just another management gimmick. But, it has proven its ability (Polaris, Minuteman) to provide management with sound information on the achievement of objectives within a project.

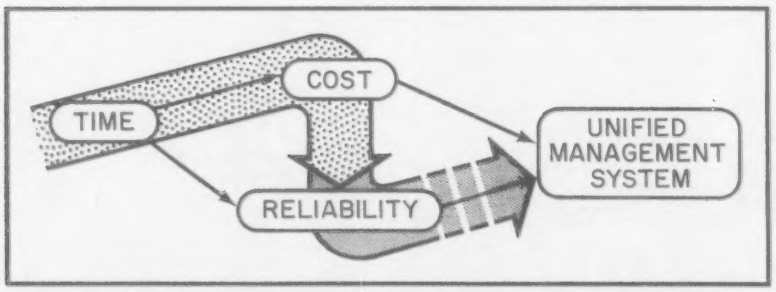
Management Measure — PERT can measure management performance. The system forces management to list what it is going to do, shows the implications on other offices involved and measures progress. Many in top management, who do not want to pinpoint weaknesses that might otherwise go undetected, have been reluctant to accept PERT.

Some critics of PERT (AM, Sept., 1961) claim that it cannot function in a crisis situation. Yet, research is underway in the application of PERT to tactical command problems. What could be more of a crisis situation?

Most existing applications of PERT deal only with time. Research has already extend PERT into cost areas. PRISM (Program Reliability Information System for Management) is being implemented by Navy's Special Projects, Operations Research, Inc. (ORI), and Lockheed Aircraft Co. Ultimately PERT will develop into a unified management information system.

PERT Costs — Cost and manpower management are being implemented in the PERT network. Basic PERT procedures are followed in obtaining project network and activity elapsed-time estimates. Activities must be homogeneous and directed to some objective or event. Additional inputs, for a PERT cost system include direct man-hours by type and employee number; direct expense items, applied or planned to be applied to an activity; and a departmental code to assist in the collection of cost data by organizational function. The system can be expanded by obtaining a range of input cost estimates or a cost function for each activity.

The vertical lines in Fig. 1 represent the integration of regular fiscal practices with PERT cost data. Planned activities cut across monthly accounting periods. It is possible to convert PERT activities to financial planning and accounting by knowing the rate of expenditure. PERT costs, in addition to being



PERT has already been extended into cost programs. Navy's Special Projects, Operations Research, Inc. (ORI), and Lockheed Aircraft Co. are implementing PRISM (Program Reliability Information System for Management). ORI research points to unified system.

Fig. 1. PERT Extension To Costs

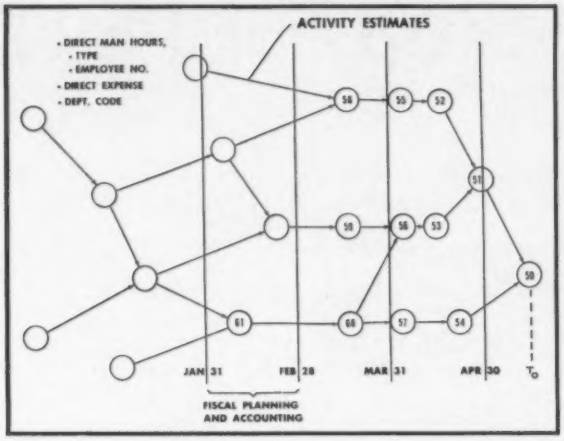
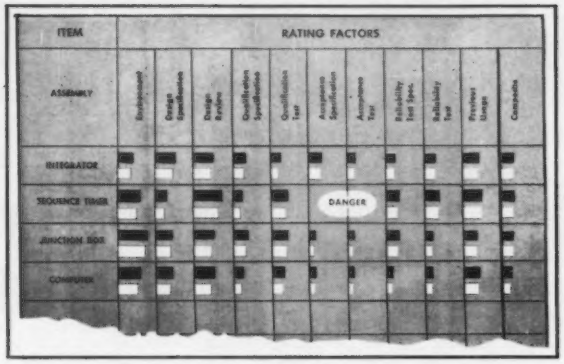


Fig. 2. Reliability Maturity Index



used directly for control, can also be considered an input to normal accounting systems.

PERT Cost Outputs — Using the basic PERT cost approach, the following outputs are obtained:

- Expected manpower requirements by skill, month and department.
- Individual man loading by month.
- Expected project direct costs by skill, month and department.
- Regular PERT time outputs, slack areas, critical path, expected calender time, and impact prediction.

Cost outputs would be used for evaluating cost-time tradeoffs, determining and improving utilization, balancing the workload, determination of percent of directed work, scheduling of manpower buildup and identification and assignment of technical work.

PERT Reliability — Project PRISM (Program Reliability Information System for Management) is being implemented by Navy-ORI-Lockheed. PRISM method will be used to estimate and monitor the reliability status of fleet ballistic missile systems. PRISM objectives are:

(1) To develop a capability to provide performance trade-off information concerning the program;

(2) To develop a capability to quantitatively depict the expected reliability on the subsystem level; and

(3) To provide a means for technical management to define and assess the activities making up a reliability program.

Two approaches are being followed in PRISM. One approach, RPM (Reliability Performance Measure) is directed to the development of a method for predicting quantitatively the ultimate user reliability of the FBM system. This method is designed to make predictions from data derived from existing practices at each stage of the development cycle.

The second approach, RMI (Reliability Maturity Index), deals with the definition, and compliance with, planned activities in the development process that have been designed to insure or measure reliability. Each item of an assembly is rated in accordance with the factors shown in Fig. 2. Check lists are built up for each of rating factors shown. This permits assignment of a rating from zero to 1. The composite rating for each item represents an index of the reliability maturity.

Unified System - Research at Operations Research Inc. is directed toward integrating cost and manpower with the PERT time system. Such a unified management information system, would operate in the planning, scheduling and production phase of an operation. It would provide cost information for the following functions: Budgeting, cost accumulation, and cost projection.

Information on manning requirements and manloading would be provided to assist in manning assignments. Such information would also be used in evaluating the effect of reassignments on the end objectives.

ORI's Institute for Management Dynamics offers courses in both PERT time and PERT cost analysis. These courses are presented either in-house or in ORI's Santa Monica, Cal. or Silver Springs, Md. locations. Plans are being made to present a course in PERT reliability.

PERT is only as good as the people operating it. Any difficulties with PERT in the future will not be caused by the system itself, but by the people running it.

✦

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Scheduling and Control by Automated Network Systems

. . . SCANS . . .

a sophisticated management technique developed as a follow-on to PERT

by Byron L. Fry, Staff Executive
Systems Development Corp.

SCANS is a more comprehensive and sophisticated version of the project management system PERT which the Navy applied so successfully to the Polaris program. Its application as a management planning tool at System Development Corp. (SDC) is to help the company do a better job more efficiently for its customers.

In January 1958, the Navy established Project PERT (Program Evaluation Research Task) to study the application of statistical and mathematical methods to the planning, evaluation and control of the program of the Navy Special Projects Office. The project team included people from the Special Projects Office, from Booz, Allen and Hamilton, and from Lockheed Missile Systems Office. As the methodology was developed, it was applied to the over-all Fleet Ballistic Missile program where it has been credited with shortening the development of the Polaris missile system by two or three years.

After the PERT system had proven itself, some members of the original development team joined SDC (in what was then the Management and Operation Research Directorate) where they undertook a study of the feasibility of extending the original scheduling capability to include two new dimensions—manpower and cost planning. A practical methodology was developed and named SCANS, Scheduling and Control by Automated Network Systems.

SCANS Philosophy — SCANS provides a powerful tool for effective management by:

- Breaking a major objective into smaller, more easily manipulated elements.
- Pointing up inter-relations of elements in time, resources and cost.

SCANS differs from the PERT system in two important ways. PERT requires three estimates of calendar time—the most pessimistic, most optimistic and most likely—for completing each activity or job; SCANS requires only one estimate of calendar time for each milestone or job. PERT is only a scheduling system; SCANS, in addition to scheduling, incorporates the other two basic ingredients necessary for management control — cost and manpower loading.

The best way of explaining SCANS is to describe its application to a very fundamental project: the remodelling of the Systems Simulation Research Laboratory. This represents a major objective (the completion of the new laboratory facilities) which involves a finite length of time, utilization of resources and cost limitations. The main objectives can be broken down into discrete steps (milestones) which involve various subcontractors and trades (resources) who have to work in an ordered sequence (schedule). The steps, in this case, consist of such things as demolition, plumbing, electrical power, air conditioning, flooring, painting, etc. The amount of resources required for each step can be defined in terms of manpower and materials. The time of application of these resources establishes the schedule.

What SCANS Shows—By using the SCANS computer program, the basic data on the individual milestones can be put into the computer, and the computer will analyze it and produce an output which then can be diagrammatically represented in the form of a SCANS network. This network will show:

- Time required to complete each milestone.
- Relations between milestones.
- Time required for a completion of the whole project.
- Milestones which will critically affect the completion date.
- Periods of slack which can be adjusted to optimize scheduling.
- Manpower loading and costs.

If changes are proposed, the relevant information can be put into the computer which will run through the network automatically and provide information about the manner in which the proposed change would affect dependent activities as well as the final completion date of the project.

System Flexibility—Complexity of projects to which SCANS can be applied is limited only by the capacity of the computer involved and the capability of the analysts assigned to the project. Nature of the system is such that it can be adapted readily to breaking extremely - complex projects into sub-projects, and establishing and processing partial networks where desirable.

The initial SCANS program is being written in machine language for the 709/7090. Parallel effort will be directed toward developing a version in JOVIAL, an SDC developed machine independent programming language, answering the need for a common standard of communications between the users of many different computers.

◆

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Men on the Move

W. LEWIS WHITTIER named Deputy General Manager of Douglas Aircraft Co.'s aircraft div. JESSE L. JONES becomes v.p. and Deputy General Manager of Missiles and Space Systems div and ROBERT L. JOHNSON is director of product development.

JAMES W. BRYAN promoted to West Coast area manager for Beech Aircraft's aerospace div.

LEE B. LEDFORD, JR., appointed assistant to pres. at Kollsman Instrument Corp.

Frederick Stevens
Northrop

Dr. William J. Perry
Sylvania

DR. WILLIAM F. BALLHAUS named executive v.p. of Northrop Corp. FREDERICK STEVENS appointed corporate v.p.

DR. WILLIAM J. PERRY appointed director of Sylvania's Electronic Defense Labs.

ROBERT W. BINGHAM named manager of Fairchild Stratos' XE-2 drone project. WALTER J. SCHAFER named director of engineering for Fairchild's Aircraft-Missiles Div.

SAMUEL JURICH has joined Computer Control Co., as senior development engineer.

DR. EUGENE T. BOOTH, JR., named v.p. and scientific director of Laser, Inc., new American Optical subsidiary.

RICHARD F. POST appointed head of Military and Industrial Products Dept. at Aircraft Radio Corp.

CHARLES F. MC MORROW has joined General Mills Electronics Group as associate director, R & D.

CLIFFORD E. WILLIS appointed v.p. of operations at Avien, Inc.

J. V. NAISH elected a director of McDonnell Aircraft Corp.

LOUIS B. YOUNG appointed general manager of Bendix Systems division.

J. J. RENDOS promoted to assistant manager of Air Reduction Sales' Cryogenic Engineering Dept.

C. ROBERT IRVINE named General Operations Manager for the Richmond plant of Avco's Electronics and Ordnance Div.

NEIL P. WHITNEY appointed president of Aircraft Radio Corp.

HOWARD W. HILL named executive v.p. of Zero Mfg. Co.

MELVIN J. ALBOM named chief metallurgist at Marquardt's Van Nuys plant.

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Dr. K. O. W. Sandberg
Bell

William S. Heavner
Bell

J. P. Field
Bendix

Charles H. Kenerson
Bell

Leslie Mollon
Brooks & Perkins

Lee N. Mortenson
Wyle

J. P. FIELD promoted to director of programs at the Bendix Mishawaka Div. E. F. LAPHAM named Typhon program manager and T. S. TORIAN, Talos program manager, reporting to Mr. Field.

WILLIAM S. HEAVNER named staff director of programs and plans for Avionics Div., of Textron's Bell Aerosystems Co. CHARLES H. KENERSON named director of marketing, and DR. K. O. WILLIAM SANDBERG named assistant to manager, of Bell's Aerospace-Rockets Div.

JOHN J. CONNOLLY promoted to v.p. of Litton Systems and general manager of Data Systems Div.

DR. LESTER C. VAN ATTA appointed technical director of Hughes Aircraft's research labs at Malibu.

WARREN C. DUNN named Military Products Marketing Manager of Lear's Electro-Mechanical Div.

DAVID F. SANDERS named v.p. of Lockheed Aircraft and continues as pres. of Lockheed Electronics.

WILBUR W. BAILEY appointed director of plans for marketing dept. of Philco's Government and Industrial Group.

JACK D. KOSER and J. A. OGLE join long-range military planning staff of Bendix.

FRED A. PAYNE, JR., appointed Assistant Director of Defense R & D for Strategic Weapons by Dept. of Defense.

EDWARD RAY and VICTOR E. BOCCELLI were recently appointed managers of new organizations in the projects planning and special programs operation at General Electric MSVD.

C. DANIEL MAY, JR., is now head of the tactical communications systems department at IBM-Rockville, Md.

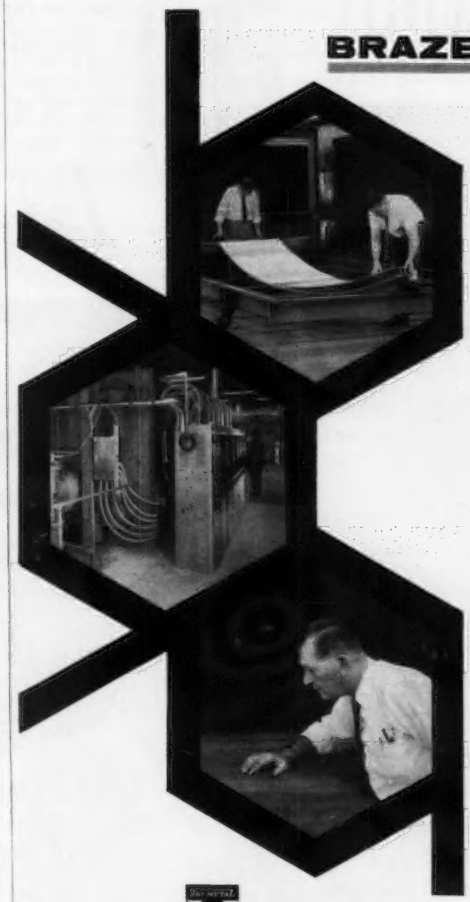
ROBERT H. OVERSMITZ has been appointed design specialist at General Dynamics/Convair in hydrodynamic research and development.

LESLIE MOLLON has been named program manager, air cargo handling systems, Brooks & Perkins, Inc.

LEE N. MORTENSON appointed manager, R & D Analysis Dept., of Wyle Laboratories.

ANNOUNCING

BRAZED ALUMINUM HONEYCOMB PANELS



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RECOMMENDED SERVICE—(1) Fluid loading arms. (2) Expansion Joints. (3) Gimbal/Rotary Swivel motion. (4) Shock resistant flexible piping.

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Circle 26 on Inquiry Card

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Circle 27 on Inquiry Card

NEW Worth Asking For LITERATURE

Space Technology

Eight-page pamphlet describes the main features of the first large space center built in the U. S. by private industry.—*General Electric Co., Missile and Space Vehicle Dept.*

Circle 101 on Inquiry Card for more data

Recovery

Capabilities and facilities of company engaged in design, development and production of recovery, landing and retrieval systems for aerospace applications. — *Space Recovery Systems, Inc.*

Circle 102 on Inquiry Card for more data

Data Recording

Modular digital data systems for alarm scanning and digital recording of virtually any type or combination of analog values are described in an eight-page brochure. — *Monitor Systems, Inc.*

Circle 103 on Inquiry Card for more data

Compressed Gas Forming

New concept in high-rate energy metal forming uses compressed gas as the driving force. Called Dynapak, process is said to eliminate metal chipping and metal loss. Bulletin 101 gives detailed information and specifications. — *General Dynamics Corp. Advanced Products Dept.*

Circle 104 on Inquiry Card for more data

Research Facilities

Brochure includes facilities and capabilities of research firm and its manufacturing division. — *Research Inc.*

Circle 105 on Inquiry Card for more data

Nanocircuitry

Booklet describes company's activities in the field of nanocircuitry.— *General Instrument Semiconductor Div.*

Circle 106 on Inquiry Card for more data

Cooling Electronics

Catalog includes 40 pages of equipment and describes facilities and capabilities of manufacturer of cooling equipment for electronic applications.—*McLean Engineering Lab.*

Circle 107 on Inquiry Card for more data

Spectroscopy Bibliography

Pocket-size bibliography on ultraviolet, visible, and near-infrared spectroscopy. 36-page booklet containes more than 250 references under headings of General, Technique and Application. — *Beckman Instruments Inc.*

Circle 108 on Inquiry Card for more data

Recorder/Reproducer

Instrumentation Recorder/Reproducer is described in brochure. Instrument features all solid-state signal electronics which records in direct FM, PDM or PCM modes.— *Ampex Corp.*

Circle 109 on Inquiry Card for more data

Guide to Spring

Brochure entitled Guide To Lower Assembled Costs For Products Containing Springs, is designed to aid in controlling costs of handling, quality and procurement.—*Associated Spring Corp.*

Circle 110 on Inquiry Card for more data

THIS NEW PACIFIC DESIGNED FURNACE BRAZES THRUST CHAMBER OF THE F-1 ROCKET ENGINE —and avoids the prohibitive height of an enlarged bell furnace which would have required an extremely tall structure to permit it to be lowered and raised. Pacific Scientific engineers —working in close cooperation with Rocketdyne personnel—developed a unique design that utilizes a common base for heating and cooling. This new brazing concept permits the two gas heating sections to move on rails to surround the airtight retort containing the large unbrazed thrust chamber. Brazing completed, the heating sections withdraw and the two watercooled sections move in to speed the cooling process. **Less than 40 seconds are needed to change from the heating to the cooling cycle.**

Furnace temperatures and atmospheres—argon, nitrogen and hydrogen, in any sequence—are rigidly controlled from a special console panel as are all other operations. Standing 25 feet tall with a diameter of twenty feet, this new brazing furnace is installed at Rocketdyne, a division of North American Aviation, Inc., Canoga Park, California. As another FIRST for Pacific Scientific —it is the world's largest brazing furnace of its kind— either electric or gas fired.

For further information on this —and other Pacific designed and built furnaces—write today to **PACIFIC SCIENTIFIC COMPANY, P. O. Box 22019, Los Angeles 22, California.**

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ROCKETDYNE'S TOWERING COLOSSUS

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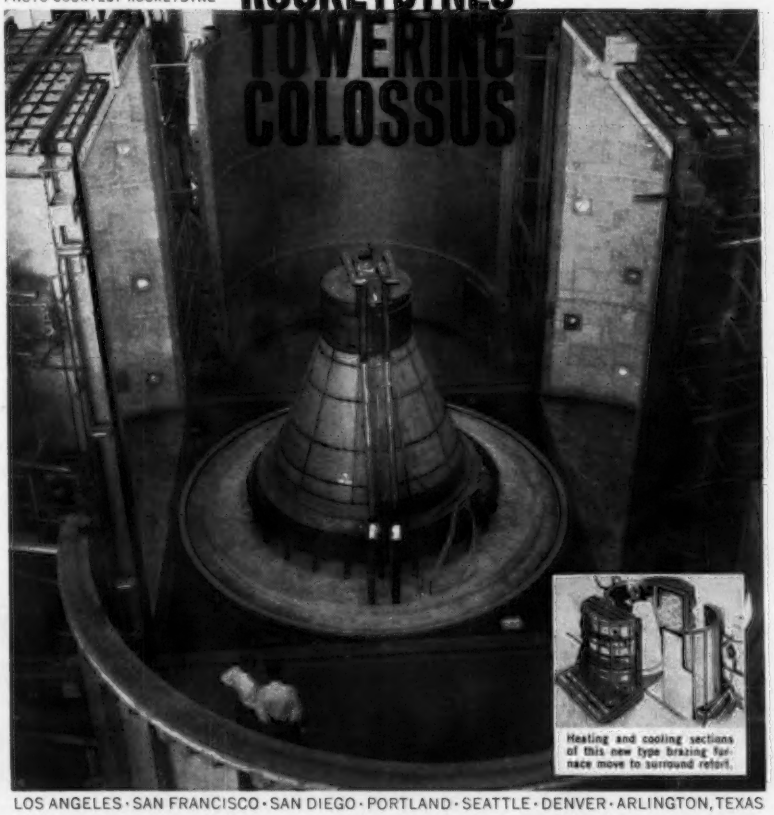

Heating and cooling sections of this new type brazing furnace move to surround retort.

LOS ANGELES · SAN FRANCISCO · SAN DIEGO · PORTLAND · SEATTLE · DENVER · ARLINGTON, TEXAS

NEW LITERATURE

Worth Asking For

. . . continued

Degreasing Equipment

Booklet describes trichloroethylene and degreasing equipment. Includes history and activities of Swedish manufacturer. — *Uddeholm Co. of America, Inc.*

Circle 111 on Inquiry Card for more data

Circular Slide Rule

Pocket-size calculator comes complete with instructions. Offered free to engineers and executives.—*General Industrial Co.*

Circle 112 on Inquiry Card for more data

Ultrasonic Cleaning

Catalog includes line of equipment, information on purchasing, and an introduction to ultrasonic cleaning.—*National Ultrasonic Corp.*

Circle 113 on Inquiry Card for more data

Temp Control

The Case of the Missing Element is a booklet in non-technical language describing concepts of aircraft temp control.—*Barber-Colman Co.*

Circle 114 on Inquiry Card for more data

High Strength Steel

Booklet describes a new steel offering tensile strength values above 360,000 psi with safe ductility. Steel is said to have a yield strength of 290,000 psi.—*Vanadium Alloys Steel*

Circle 115 on Inquiry Card for more data

Resin Prepregs

Properties and applications of prepregs based on diallyl phthalate resin. Bulletin deals with molding procedures and also with diallyl isophthalate prepregs. — *Dapon Dept. FMC Corp.*

Circle 116 on Inquiry Card for more data

Machining Computer

Pamphlet describes how computer handles complex machining problems economically for aircraft parts manufacturer.—*Remington Rand Univac*

Circle 117 on Inquiry Card for more data

Silicon Rectifier

Brochure contains 19 curves including NEMA overload ratings on high current silicon rectifiers. Instructions for calculating some recurrent overload ratings are included.—*General Electric Co.*

Circle 118 on Inquiry Card for more data

Nylon Slings

Booklet describes a line of nylon and dacron slings that have a pound safety factor of 5 to 1. Slings available in many widths and lengths.—*The Caldwell Co., Inc.*

Circle 119 on Inquiry Card for more data

Anechoic Chambers

Brochure describes 14 microve anechoic chamber designs. Sizes shown range from 100 ft long to as small as 40 ft. Data is given on results of radar cross section measurements of several Eccosorb Anechoic Chambers.—*Emerson & Cuming, Inc.*

Circle 120 on Inquiry Card for more data

Clean Rooms—Gray Rooms

Paper on clean rooms, requirements and construction. — *Unistrut Products Co.*

Circle 121 on Inquiry Card for more data

Douglas needed a superalloy bellows assembly for the auxiliary power unit exhaust system on the U. S. Army's Nike Zeus. Assembly had to withstand violent movements in operation under critical temperatures. Avica samples met all test requirements. When Douglas was required to meet an urgently accelerated missile shot at White Sands, N. M., within a week, they immediately turned to Avica. Modifications were required and close on-the-spot coordination of design specifications resulted in a successful modification program. Avica made 16 units and shipped order complete in 4 days. Douglas received parts 6 days from time of order, flew them to White Sands in time for scheduled shot.

Douglas Aircraft Company is part of the Army Ordnance-industry team developing the Nike Zeus Anti-missile System. Western Electric Company is the industrial prime contractor.

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NEW Materials

Hi Temp Plastic

Engine nozzle liners for Polaris missles are compression molded from Refrasil. Material is said to undergo pressure of 4000 psi at 320° F for

60 min. Parts will withstand temp extremes for limited periods of time. — *Plastics Div., Lockard Tool and Engineering Co.*

Circle 122 on Inquiry Card for more data

Low Viscosity Resins

Two low viscosity epoxy resins are available for filament winding systems requiring high tensile elongation and good handling characteristics. It is further claimed that these resins are also useful for laminating applications. Resins cure with anhydries and aromatic amines at room temp. — *Union Carbide Plastics Co.*

Circle 123 on Inquiry Card for more data

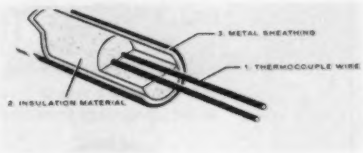
Columbium Base Alloys

Two columbium base alloys have become commercially available. D-14 (a binary containing zirconium) and D-36 (a ternary containing titanium and zirconium) can be fabricated, welded and coated by normal methods. It is claimed that they retain useful strength at temp above 2500° F.— *Du Pont Metals Center*

Circle 124 on Inquiry Card for more data

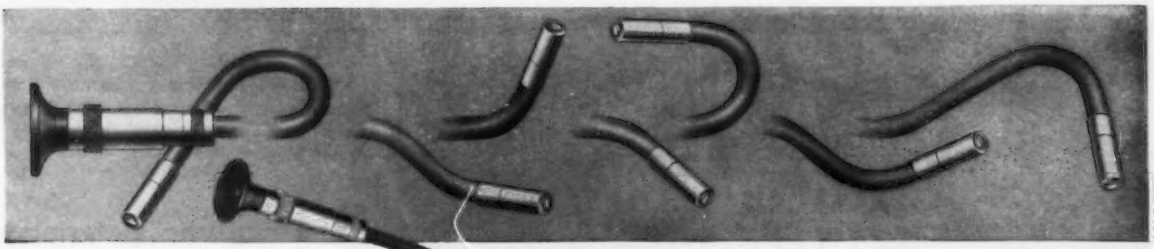
Thermocouple Material

Ceramic-insulated, metal-sheathed thermocouple material is said to be spectrochemically clean. Material provides own insulator and conduit and provides protection against corrosion, high pressure, vibration and temp extremes. Called Tempak, the material will measure temp of products of combustion of kerosene and



air at high temp and pressure, and measure exhaust gas temp at various stations of a turbo-jet engine. — *Temptron, Inc.*

Circle 125 on Inquiry Card for more data



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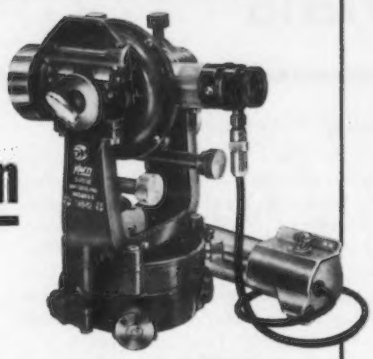

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Circle 32 on Inquiry Card

NEW Materials

continued

Metal-Plastic Compound

Compound is said to be ideal for making low-cost tools used in forming thermosetting plastics. Supplied as a dry powder, the material can be poured into a mold and liquefied by heat. It can be cast net size with tolerances as close as .001 in. Material was developed jointly with the Boeing Co. — *American-Marietta Co.*

Circle 126 on Inquiry Card for more data

Spray Refractory

High-strength castable refractory can be placed with wet or dry gun methods. It is further claimed that

material can be used at 2500° F, has excellent abrasion resistance and resistance to thermal shock. — *Babcock & Wilcox Co.*

Circle 127 on Inquiry Card for more data

Ferrimagnetic Materials

New materials can be synthesized to control the effective internal anisotropy field over values that make the materials suitable for X and V band applications. It is further claimed that the crystalline anisotropy field of these oriented polycrystalline barium ferrites can be used to augment or replace the usual externally applied magnetic field.— *Sperry Microwave Electronics Co.*

Circle 128 on Inquiry Card for more data

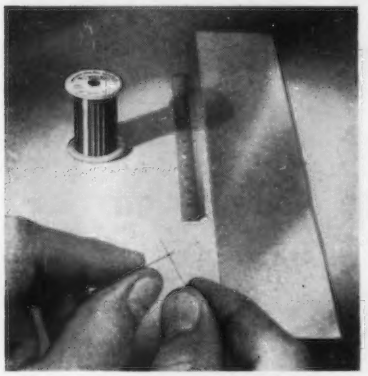
Radiation Shield

High density polyethylene is said to have resistance to radiation damage, stability and shielding capabilities. Mixed with boron, the material shields secondary gamma rays as well as neutrons. Material is being developed for use with nuclear propulsion units.—*Phillips Chemical Co.*

Circle 129 on Inquiry Card for more data

Tungsten-Rhenium Wire

Expanded line of high temp refractory metal alloys is offered. Tungsten-rhenium alloy is produced



in fine wires (0.0005 in.) and strips in 4 in. widths (0.005 in. thick). Firm is working to increase range of sizes for this and other refractory-type alloys, such as molybdenum-rhenium. — *Hoskins Mfg. Co.*

Circle 130 on Inquiry Card for more data

Silicone Process

A thin coating of silicone fluid, applied to stainless steel prior to heat treat, inhibits formation of scale. The fluid (Dow Corning 200 Fluid 50 centistokes viscosity) is used in process developed by the Boeing Co. They claim total metal loss during one heat treat and descaling operation is kept down to 0.1 or 0.2 mils. — *Boeing Associated Products, Boeing Co.*

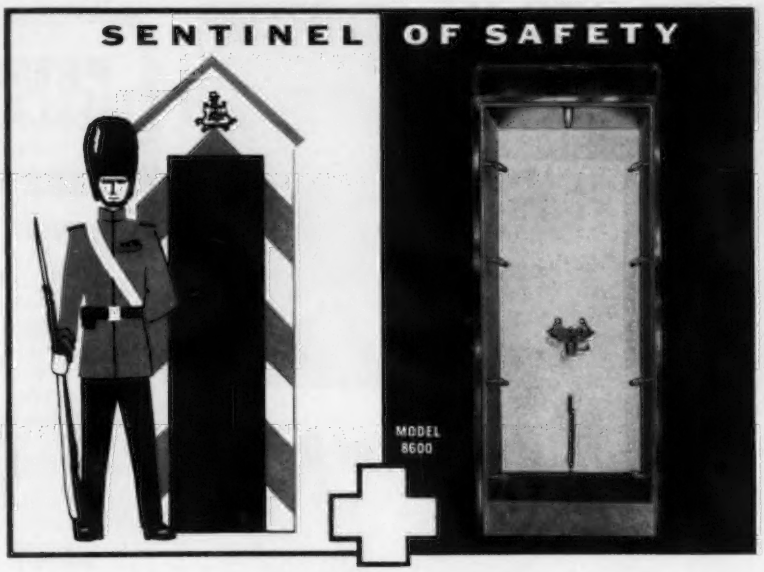
Circle 131 on Inquiry Card for more data

Carbon Fabric

Material, available in fabric rolls and fiber form, is said to possess low thermal conductivity and low ablation rate when combined with phenolic resins. Called Hitco-C, the material is virtually pure carbon. It is compatible with most resin systems

and with reinforced-plastic fabrication techniques. — *H. I. Thompson Fiber Glass Co.*

Circle 132 on Inquiry Card for more data



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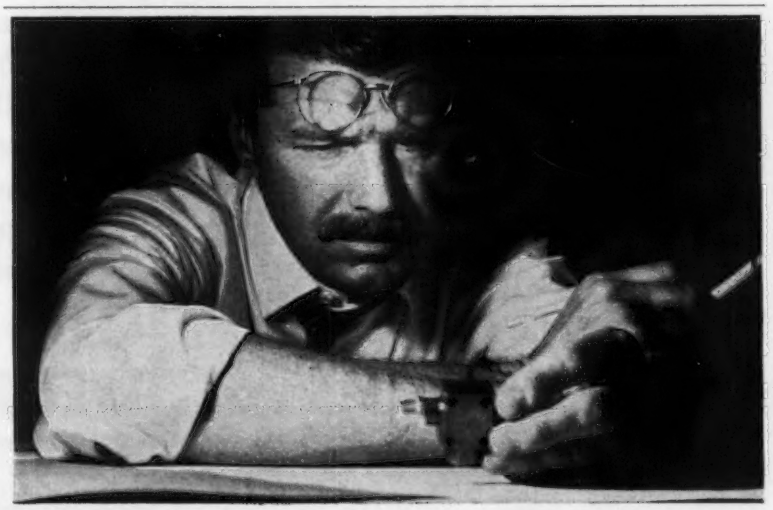

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If your problem involves combining a sizeable force with light weight for positive, instantaneous operation, talk to the Pacific Division about propellant actuated devices. We have a wealth of experience in space vehicle applications, aircraft escape systems and ejectors for separation of airborne stores. Cartridge-actuated pin valves, pin pullers and other mechanisms can be used in many ways to accomplish a specific task. Our extensive facilities for engineering, manufacturing and testing are available. Call or write today.

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Delta Air Lines uses this Tinius Olsen Vertical Static Balancing Machine to pinpoint minute amounts of unbalance in jet turbines and compressor components.

Find out all the advantages of the **Olsen** precision method of balancing. Send today for Bulletin 60. Tinius Olsen Testing Machine Company.

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Sinclair-Collins' diaphragm-operated high pressure valves provide fast and positive control of ultra-high pressure air, tight sealing, compact size, ample safety factors.

Available size, 2 in. NPT; flanged mounting; 2-way normally open or normally closed; for direct or remote electro-pneumatic control. Ask your Sinclair-Collins Field Engineer for specific recommendations.

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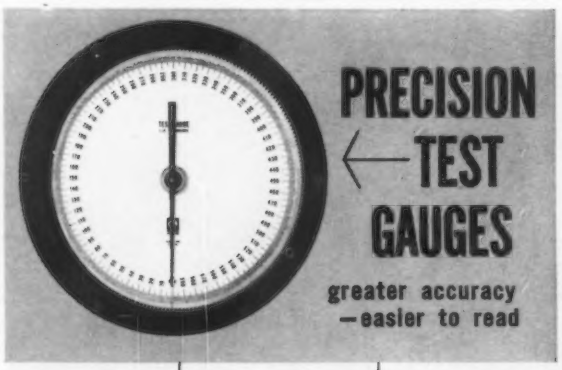

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Guaranteed accuracy ± .15%, including factors of temperature, hysteresis and calibration.

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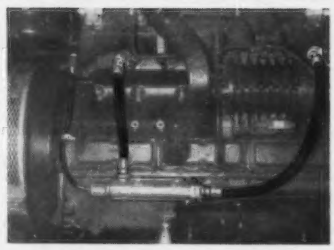
Circle 36 on Inquiry Card

KIM HOTSTART Diesel and Gasoline Engine Pre-Heater



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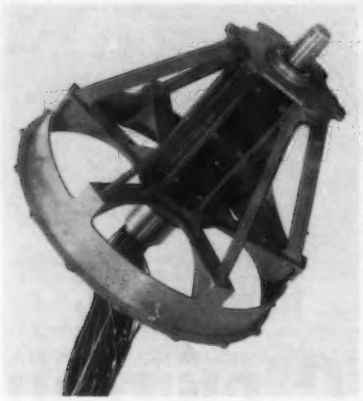
Circle 38 on Inquiry Card

NEW Electronic Products

Slip Rings for Space

Line of slip rings designed for space environment are available with

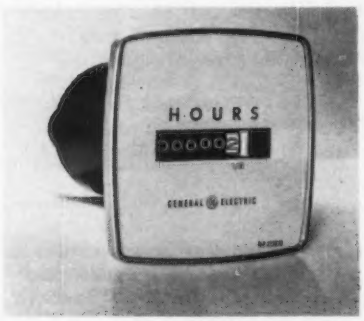


up to several hundred circuits. Unit shown was designed for Midas satellite.—*Slip Ring Co. of America*

Circle 133 on Inquiry Card for more data

Time Meter

Sealed models of an elapsed time meter are now available for military applications. Meters are built in 2.5 and 3.5 in. models for panel mounting and will measure up to 99999.9 minutes or hours. Electrical ratings



available include 120, 208, 240 and 480V models for 50 or 60 cycle operation.—*General Electric Co.*

Circle 134 on Inquiry Card for more data

Data Transmission

Technique, named DEFT (Dynamic Error-Free Transmission) is claimed to be capable of sending up to 15,000 words per min over ordinary telephone lines. DEFT phase modulation technique incorporates alphanumeric characters which are coded into phase relationships among simultaneously transmitted tones. Character recognition technique does not require either dynamic logic or storage circuitry. — *General Dynamics/Electronics*

Circle 135 on Inquiry Card for more data

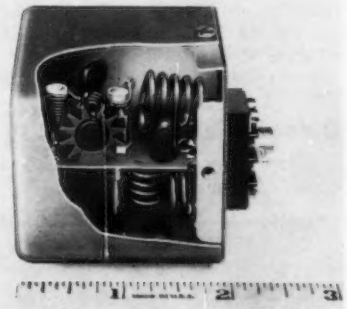
Mini Power Transistor

Silicon transistor line is said to have greatly increased saturation resistance. This feature allows them to switch power up to 120 watts without use of a heat sink. Volume is .028 cu/in. — *Silicon Transistor Corp.*

Circle 136 on Inquiry Card for more data

Mini Radio Beacon

Cutaway illustration shows details of miniature radio beacon. Beacon is one of group of eight beacons covering a portion of the 2-260 mc



region, with ranges up to 200 mi. Two in. cube shown weighs five ounces and is said to provide half a watt of output power at 242 mc. Input power required is 26 V at 200 ma. — *Sunnyvale Development Center, Sperry Phoenix Co.*

Circle 137 on Inquiry Card for more data

Magnetic Computer

Digital computer is said to be capable of operating reliably 40 times longer than comparable equipment. Unit weighs 19 lb and is less than half-a-cubic-ft. Unit can handle 12,000 computations a second. — *Sperry Gyroscope Co.*

Circle 138 on Inquiry Card for more data

Message Distribution

Semi-automatic teletypewriter message distribution system receives messages from several incoming teletypes, electronically remembers them and routes then according to time of

arrival and priority classification to as many as 105 receiving teletypes. — *Minneapolis-Honeywell Regulator*

Circle 139 on Inquiry Card for more data

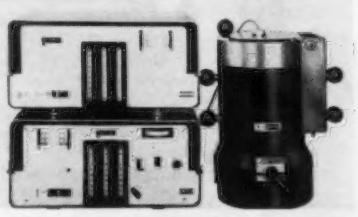
Gas Generator

Industrial gas generator is said to maintain near perfect dissociation efficiency, with 200 cfh capacity. Unit requires 15 sq/in of floor space. Unit incorporates a tubular inconel free-flow retort, permanent nickel-type catalyst and 80-20 alloy heating elements.—*Lindberg Engineering Co.*

Circle 140 on Inquiry Card for more data

Alpha/Beta Counter

Single-detector proportional counting system counts both alpha and beta radiation independently and si-



multaneously from the same sample. Transistorized system consists of a universal shield (right) and two decade scalers (left). — *Nuclear Measurements Corp.*

Circle 141 on Inquiry Card for more data

. . . *continued on next page*

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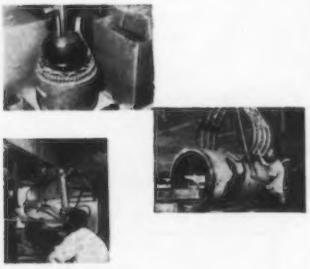

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Circle 39 on Inquiry Card

NEW Electronic Products

continued

Aircraft Energizer

Self-propelled ground power unit for aircraft is said to be capable of providing DC ground power for all piston engine aircraft and for some

turbo-prop aircraft. 400 cycle power is available to support the 707, 720, DC-8 and others. — *Motor Generator Corp., Hobart Brothers Affiliate*

Circle 142 on Inquiry Card for more data

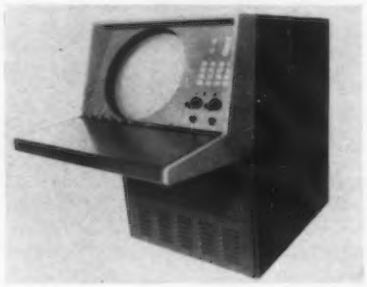
Electroluminescent Panels

Crossed grid electroluminescent panels are claimed to be the world's largest. Units are designed for use in data processing, radar, countermeasures and air and sea traffic control. Crossed grid panel has a resolution of 16 lines per in. — *Sylvania Electric Products*

Circle 143 on Inquiry Card for more data

Direct View Display

Direct-view display console is designed for monitoring digital com-



puters. Console is expected to be useful in man-machine information systems. —*General Dynamics Electronics*

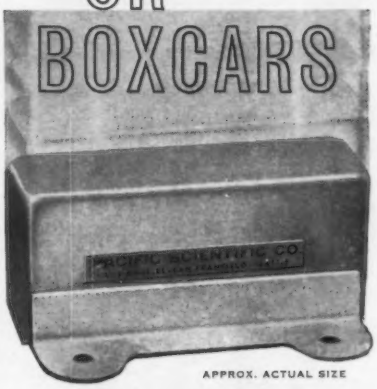
Circle 144 on Inquiry Card for more data

Humidity Meter

Transistorized humidity meter is said to give relative humidity readings with a plus or minus 2 per cent accuracy. Unit can be used as a permanently wired-in instrument for monitoring and read-out. — *Telostat*

Circle 145 on Inquiry Card for more data

FOR "BIRDS" OR BOXCARS



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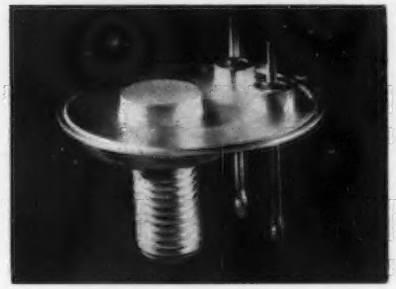
Circle 40 on Inquiry Card

NEW Parts and Components

Pre-Finished Bases

Brazed semiconductor base assemblies feature joined glass-sealed pin terminals, weld ring, base plate and



threaded copper heat sink. Unit shown, for power transistor header, combines stainless steel base plate and copper heat sink with gold-plated molybdenum disc brazed to stud pedestal.—*Standard Pressed Steel*

Circle 146 on Inquiry Card for more data

Image Converter Camera

Camera is claimed to be a complete diagnostic tool for instrumentation of high speed luminous transient events encountered in plasma physics, chemical kinetics and hypervelocity experiments. It is said to be capable of taking framed photographs at exposure times varying from 3 to 200 millimicroseconds. Three-picture series can be made at rates of half a million to twenty million exposures per second. Streak photographs may be taken at writing speeds of 4 to 1000 millimeters per microsecond.—*Space Technology Laboratories*

Circle 147 on Inquiry Card for more data

Explosive Arresting Bolt

Explosive bolt will support a drag hook for emergency aircraft stop systems. Under normal conditions the bolt will hold a spring loaded drag hook in place within the fuselage. Under emergency landing conditions the charge is fired, dropping the hook into position to catch fixed landing barricades such as a cable.—*McCormick Selph Associates*

Circle 148 on Inquiry Card for more data

Hot Gas Tubing

Super alloy tubing (Hastelloy X) has a high melting temp of 2350° F and high temp strength and oxidation resistance to 2350° F. Welded and drawn tubing is being used by Sundstrand in jet starters for F-100 and B-52H aircraft.—*Superior Tube Co.*

Circle 149 on Inquiry Card for more data

Life Raft

Inflatable life raft for private aircraft is available in 4 or 8 man capacity. Rafts feature double the buoyancy needed for maximum capacities with two separate buoyant chambers. Equipment includes aluminum oars, rowing seat, hand inflation pumps, and automatic inflation system.—*Air Cruisers Div., Garrett*

Circle 150 on Inquiry Card for more data

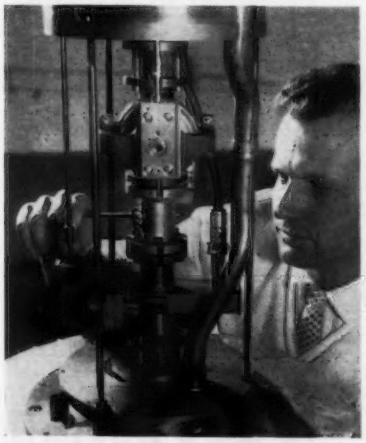
Temp Sensor

Immersion-type platinum resistance temp sensor is said to be effective at temp from −435° to 500° F. Sensing element is protected by a stainless steel well and has a 0.2 sec time constant. Unit was designed for storable fuel applications but can be used in the temp range in any fluid compatible with stainless steel.—*Rosemount Engineering Co.*

Circle 151 on Inquiry Card for more data

Klystrons

Extended interaction klystrons are expected to multiply by four times the output of high power amplifiers. An adaptation of a circuit devised for speeding electrons in atom smashers

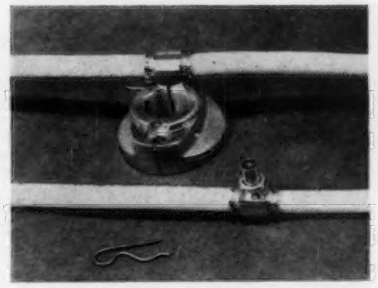


could conceivably double a communications systems capacity. An experimental model is shown.—*Sperry Electronic Tube Div., Sperry Rand Corp.*

Circle 152 on Inquiry Card for more data

Separation System

Stage separation system is based on the development of a new frangible nut and integral dual explosive



train. In operation, the nuts are torqued to bolts joining two missile stages, normally eight to twelve bolts. Explosive charges are part of harness which interconnects all nuts in the system. An electrical impulse ignites the dual explosive train and sequentially (3 milliseconds), each of the cartridges in the system.—*Special Devices, Inc.*

Circle 153 on Inquiry Card for more data

Power System

Gas generating power system is small enough to be held, transported and operated by hand. As a device for inflation, the system will produce cool gas to inflate units 1 to 500 cu ft in volume at pressures from 3 to 3000 psi. As an auxiliary power system, it provides high pressure gas. Additionally it is claimed that as a reaction device, the system will provide controlled thrust for orientation and stabilization or can be used as an emergency power source in manned space capsules. The device uses many small solid-propellant gas generators which when expended are replaced, much the same as cartridges in a rifle.—*Aircraft & Missile Consultants*

Circle 154 on Inquiry Card for more data

Photoelectric Encoder

Photoelectric setting device for converting barometric readings to digital information was designed for nuclear weather station. A photoelectric encoder was mated to an altimeter setting indicator. Instrument will be used to transmit barometric pressure data in digital form twice in a 17 sec period at three-hour intervals.—*Kollsman Instrument Corp.*

Circle 155 on Inquiry Card for more data

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Penetrates, lubricates, prevents rust. Lubricates deep into chain linkage to reduce friction on pins, rollers, bushings, pressure surfaces. Corrosion inhibitor prevents rust in vital working mechanisms. Lubricates close-tolerance internal surfaces to increase chain life up to 300%. Highly recommended for all climatic conditions to stop rust and corrosion even in salt atmospheres.

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Circle 41 on Inquiry Card

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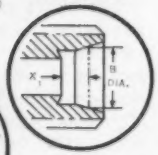

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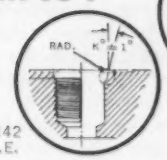

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Circle 42 on Inquiry Card

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Circle 43 on Inquiry Card

NEW Parts and Components

continued

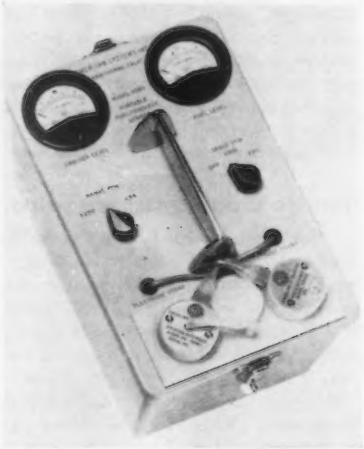
3 Axis Rate-Gyro

High resolution telemetry sub-system for use in spin-stabilized missiles is said to accurately measure rates during spinning speeds of up to 5000-deg/sec. Four lb self-contained unit incorporates three rate gyros to telemeter pitch, yaw and roll rates.—*Fairchild Controls Corp.*

Circle 156 on Inquiry Card for more data

Trace Sensor

Dual unit detects trace quantities of toxic rocket fuel and oxidizer. Called the Olfactron, the unit displays the ambient fuel and oxidizer vapor levels on panel meters directly. It is said to have a sensitivity of one part



in four million for fuel vapor and one in one million for oxidizer.—*American Systems Inc.*

Circle 157 on Inquiry Card for more data

Solid Tantalum Capacitors

Miniature capacitors are available in 20 v or 35 v DC voltage ratings with low capacitance ratings of 0.0047 through 0.82 microfarads. It is said that their high stability with respect to time and temp permits simplified circuit design.—*Texas Instruments, Inc.*

Circle 158 on Inquiry Card for more data

Linear Actuator

Explosive linear actuator is designed for chute ejection, valve actuation, and similar functions in target drones, missiles and rockets. Actuator weighs less than 2 oz. It is claimed that it will stroke one-half inch

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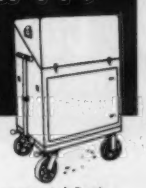

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Circle 45 on Inquiry Card

against an opposing force of 250 lb, in milliseconds.—*Holex, Inc.*

Circle 159 on Inquiry Card for more data

Miniature Recorder

Multi-channel, miniature magnetic tape recorder is said to be capable of operating through environmental ex-

tremes, including 1000 g shock and temp from —65° to 165° F. Compact recorder can record up to 14 channels simultaneously on one inch magnetic tape. Total tape capacity is 69 ft.—*Borg-Warner Controls*

Circle 160 on Inquiry Card for more data

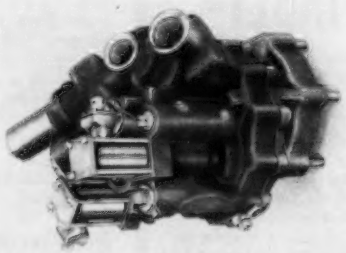
Lens Antenna

X-band lens antenna radiates a circular polarization with a hemispherical radiation coverage. It is claimed that two lens antennas properly installed on an airborne vehicle afford complete tracking coverage of yaw, pitch or roll.—*Canoga Electronics Corp.*

Circle 161 on Inquiry Card for more data

Hydraulic Motors

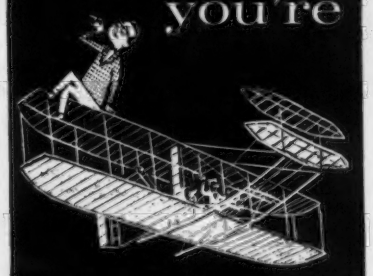
Variable displacement hydraulic motors are available with ratings from 13 to 60 hp at a differential pressure of 2750 psi. Axial piston



units serve as a lightweight source for AC power, fuel boost pumps, turbine starters and compressors.—*Vickers Inc.*

Circle 162 on Inquiry Card for more data

Suddenly you're



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AER-234

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Company _____

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City _____ Zone ___ State ___

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We also appraise _____ Gifts in the $7.50 to $100.00 price range.

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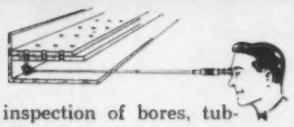

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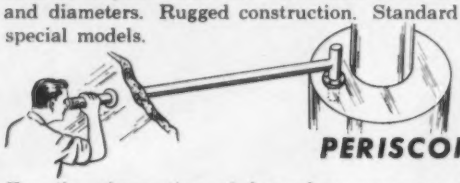
For the internal visual inspection of bores, tubing, or inaccessible assemblies. Interchangeable heads vary the angle of view; 360° circumference type head gives panoramic view. Available in all lengths and diameters. Rugged construction. Standard and special models.



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For the observation of hazardous processes from remote positions. Manufactured to fit your application—in any length, diameter, field of view or magnification. Write for literature, or outline your problem—we will be glad to make recommendations.

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measurement and control

OF PRESSURE AND DIFFERENTIAL PRESSURE

DELTADYNE® SWITCHES
Pat. No. 2,942,572
Adjustable for signalling pressure and differential pressure from 0.25" wc to 200 psi (or psid) in systems to 5000 psi and −65° to +275°F; leak-proof. Units sound alarm, light bulb, turn motor on or off, operate valves—remotely or in place. **$40 to $75**

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Adjustable and non-adjustable. Actuation 0.01 to 100 psi (or psid). For same pressure/temperature as switches. Red button pops to give visual indication of overpressure. **$22 to $85**

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For system pressures to 3000 psi; indication from 0 to 60 psi differential; leak-proof—no moving seals; high-visibility scale. **$92**

Extended pressure and temperature ranges available in all instruments.

NEW DESIGNS!

NEW ACCURACY!

OFF-THE-SHELF OR CUSTOM-ENGINEERED FOR

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Read or control tank levels, and pressure drops across filters, heat exchange orifices for flow metering, gas adsorbers and many other types of equipment. Learn more about the cost and service advantages of these units.

WRITE FOR COMPLETE LITERATURE

AIRCRAFT POROUS MEDIA, INC.
PALL — *A subsidiary of Pall Corporation*
GLEN COVE, NEW YORK

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NOW...

SAMPLE AIR FASTER, MORE ACCURATELY, PORTABLY

Accurate to 1/100 micron!

INDISPENSABLE for series or unit air sampling — indoors or out. Portable, yet stands up to heaviest usage. Weighs only 10 lbs. Comes equipped with standard 4" filter holder. Special adapters available for 6" x 9"; 8" x 10"; 12" x 12" and others.

Staplex Air Samplers are widely used to solve the many diverse, exacting needs of leading industries. Also for industrial hygiene and health departments, nuclear and missile fields; manufacture and processing of beryllium products, radioactive materials and all other industrial dusts and air pollutants.

Let us help you solve your air sampling problems as we have for thousands of users. Send for details.

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779 FIFTH AVENUE • BROOKLYN 32, N. Y.
World's Largest Manufacturer of High Volume Air Samplers

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New convenience! New economy! The Sturdilite Insert Work Top — strong, solid, 2" thick — is designed with a 16 x 24" opening to accommodate interchangeable, special purpose inserts.

The inserts are simply placed into the opening in the top — hold firm — remain flush. If work needs change or an insert becomes worn, replacement is immediate.

The standard top sizes are 30" wide by 4, 5, and 6 and 8 feet long and are offered in three finishes. The inserts, 16 x 24", are available in four different work surfaces: "HML" Plastic Laminate, Rubber Cork Composition, Benelex and Colorlith.

WRITE TODAY FOR THE FULL INSERT TOP STORY AND DETAILS ABOUT STURDILITE'S COMPLETE TOP LINE.

STURDILITE PRODUCTS, INC.
3001 Palmolive Building, Chicago 11, Illinois

Circle 50 on Inquiry Card

NEW Production Equipment

Flame Spraying

Missile components are being flame sprayed simultaneously with two quarter-in. Ceramic Rod Spray-

ing Machines. Units are equipped with extensions as the inside diam is being coated. Surface is blast cleaned with sharp non-metallic abrasive. Spraying consists of nichrome undercoat followed by zirconia to provide an effective heat barrier.—*Metco Inc.*

Circle 163 on Inquiry Card for more data

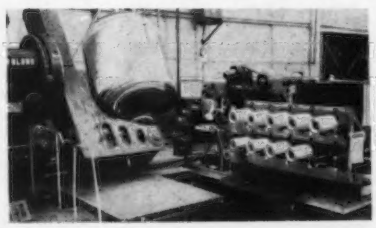
Pneumatic Computer

Pneumatic analog computer will add, subtract, multiply and divide using standard industry 3-15 psi pneumatic inputs. It will take ratios and square root, as well as integrate, differentiate, serve as a function or test signal generator and provide hold, or memory.—*AiResearch Mfg. Div., The Garrett Corp.*

Circle 164 on Inquiry Card for more data

Filament Winding

Lathe was adapted for filament winding. Workpiece is tumbled in a special cradle attached to the faceplate of the lathe, to achieve an intricate winding pattern. Special lathe was built for Aerojet-General. Company also builds ten standard lathes for missile applications ranging from



72 to 99 in. swing over cross-slide, all with 56 in. bed width and powered by 50 to 75 hp motors.—*LeBlond*

Circle 165 on Inquiry Card for more data

Aluminum Electrode

Aluminum electrode for all-position welding has an extruded coating. Called Airco 43, it is usable in flat, horizontal and vertical arc welding positions. Airco 43 comes in two sizes, one-eighth in. diam by 14 in. and five-thirtyseconds in. diam by 16 in.—*Air Reduction Co.*

Circle 166 on Inquiry Card for more data

Solid-State Computer

Computer is designed to meet metal-working industry's need for a general-purpose, medium-scale, high-capacity computer. It features processing speeds up to 1,176,470 additions or subtractions per minute, and storage capacity up to 125,400 digits. It occupies 500 sq ft of floor space. Computer's High-Speed Card Reader can read and verify up to 600 cards a minute. Computer is suitable for small job shops as well as large-scale fabricators. In addition to its numerical control programming capability, the computer can perform production control, billing, sales analysis and inventory control.—*Remington Rand Univac*

Circle 167 on Inquiry Card for more data

Plasma Gun

Compact, lightweight plasma gun designed for production-line use. Gun is 5 in. long and weighs 3.5 lb. It is claimed that the gun will spray coating, including refractories, with controlled thickness, density and bond strength. Gun can also be used to fabricate free-standing forms.—*Avco*

Circle 168 on Inquiry Card for more data

Conveyor Diverter

High speed, low shock conveyor diverter automatically diverts closely space cartons or containers from main conveyor onto predetermined spur accumulator lines at speeds up to 300 ft/min.—*Atronic Products Div., General Atronics Corp.*

Circle 169 on Inquiry Card for more data

Welding Enclosure

Inert gas welding enclosure is designed for welding rare metals, such as molybdenum, tantalum, columbium and zirconium which oxidize readily in normal air. Selective inert gases can be used with the system.—*Royal Research Corp.*

Circle 170 on Inquiry Card for more data

Impact Wrenches

Pneumatic impact wrenches have quarter-in. bolt capacity, with quarter-in. female hex quick change

chuck, three-eighths and half-in. drive squares. Available with pistol or straight type handles. Wrenches are reversible with full power in either direction.—*Airetool Mfg. Co.*

Circle 171 on Inquiry Card for more data

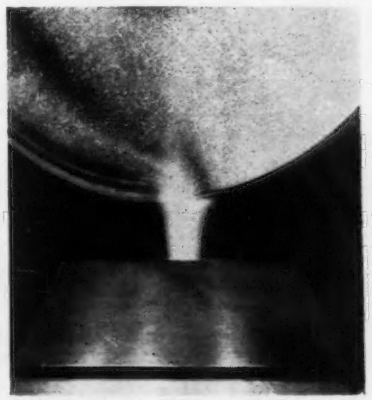
Blast Shock Simulator

Blast shock simulator for testing missile hard site ground support equipment, is designed to provide both horizontal and vertical shocks. Machine will test specimens up to 6300 lb.—*Wyle Laboratories*

Circle 172 on Inquiry Card for more data

Weld Surfacing

Weld surfacing method for depositing fully-fused overlays of wear and corrosion-resistant alloys uses argon gas to form plasma. Argon also shields surfaced area from contamination. Overlay metal is fed as a



powder into torch. It is claimed that overlays from .010 in. to 3/16 in. can be laid in one pass.—*Linde Co.*

Circle 173 on Inquiry Card for more data

CONTROL POWER

for Air and Space

POWER (fuel)

- Chemical → Mono- and Bi-Propellant and Solid
- Liquid → Liquefiable Gases
- Gas → Nitrogen, Hydrogen, Oxygen, and Helium

CONTROL (systems)

- Booster Attitude → Reaction Jet and Vane Actuating Systems
- Satellite Orientation and Rendezvous → Reaction Jet System
- Vernier Acceleration and Retro-Thrust → Proportional Thrust Motors
- Aerodynamic → Vane and Jetavators
- Thrust Vectoring → Nozzle Gimballing and Secondary Injection

by KIDDE

- Thrust Ranges → 0.01 lbs. to 600 lbs.
- Temperature Ranges (Fluid) → −65° to +6000°F.
- Response Ranges → 4 mil-seconds to 90 mil-seconds
- Total Impulse → 10 lb./sec. to 100,000 lb./sec.
- Pressure Ranges → 2 psi to 7500 psi
- Duration and Environmental Temperature (Atmosphere-Space) → −80° to +1500°F.: 15 hours

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Established 1943

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COMPANY .....

PLANT ADDRESS .....

CITY .....ZONE.....STATE.....

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Please check in A & B below (one each) which best describes:

A. Your Job Function

- ....1. Management
- ....2. Design & Engineering
- ....3. Production
- ....4. Procurement

B. Type of Plant or Facility

- ....1. Airframe
- ....2. Propulsion
- ....3. Electronic Systems & Parts
- ....4. Mechanical Systems & Parts
- ....5. Raw & Processed Material
- ....6. Engineering & Research Services
- ....7. Military & Government Facilities
- ....8. Parts & Supplies
- ....9. Plant or Test Equipment
- ....0. Other

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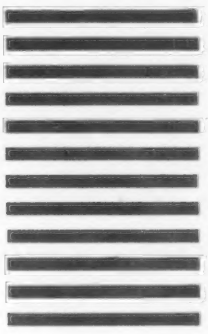

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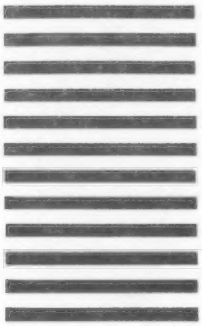

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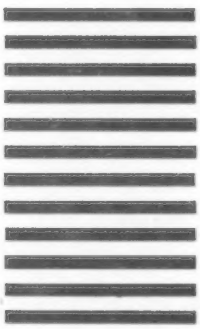

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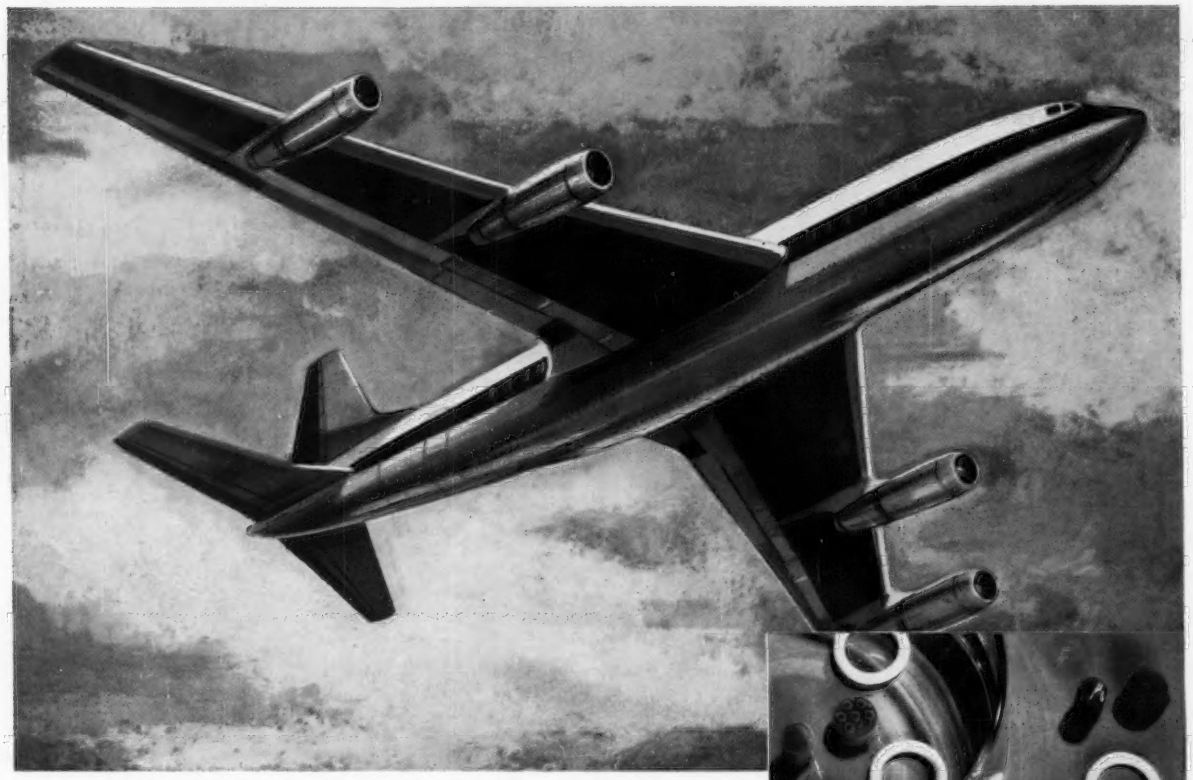
Where reliability counts



Here's why Silastic® LS is specified to seal jet fuel in . . . trouble out

Seals that come into contact with jet fuel must always perform as if they are *brand new* . . . installed only moments before take off on today's intercontinental jetliners.

Chances are, however, these seals have been in use for months. Hundreds of hours of *over-the-weather* flying have exposed them to the attack of ozone. Minutes after take off these seals can plunge from oven-like runway conditions to high altitude temperatures of —60 F. Yet, despite repeated thermal cycling and exposure to rubber-killing conditions, these seals must maintain their integrity . . . exhibit no evidence of cracking or checking. They must remain flexible in the bitter cold at high altitude to assure completely reliable operation . . . and, though they are in constant contact with jet fuel, resist swell and tenderizing.

When you study the photograph and chart of properties at right, it's easy to see why Silastic LS, the fuel-resistant silicone rubber is specified as standard material for many jetliner seals.

Silastic LS parts at left show negligible swell after prolonged immersion in JP-4 fuel. Identical parts at right were not immersed.

PROPERTIES CHART

Physical Properties	
Hardness, (Shore A)	50-65
Tensile Strength, psi	800-1000
Elongation, percent	150-170
Brittle Point	—90

Fuel Resistance (JP-4)

	Durometer Change	*Tensile Str'gth Change %*	*Volume Change %*
After 30 days immersion	—5	—31	+10

Weather Resistance	
After 31 months (3549 sun hours) at Florida Test Station	no visible effects

For information about Silastic LS and a list of part suppliers, write Department 0322, Dow Corning Corporation, Midland, Mich.

first in silicones

Dow Corning

Circle 2 on Inquiry Card

AIRCRAFT DESIGN ENGINEERS

Engineering is now underway on the strange looking bird pictured here. We call it the "Hummingbird," and we are developing it for the U. S. Army.

It is to utilize the jet ejector augmentation principle for VTOL aerial vehicles to fly straight up, straight down, hover in mid-air, and convert to conventional forward flying at speeds in excess of 500 miles per hour. Just one example of what is going on here at our Engineering Center where dreams come true. Like to join us?

Openings in the fields of: Aircraft Design Engineering • Engineering Drawings Checking • Aircraft Structures • Flutter and Vibration • Sonic Fatigue • Aircraft Specifications Engineering • Reliability Engineering • Operations Research • Aircraft Research Engineering.

Write to: Hugh L. Gordon, Professional Employment Mgr., Lockheed-Georgia Co., 834 W. Peachtree St., Atlanta 8, Ga. Department Z-78.

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

THE ENGINEERING CENTER
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